MOTION PICTURE
Making and Exhibiting

Motion Picture Making and Exhibiting

A comprehensive volume treating the principles of motography; the making of motion pictures; the scenario; the motion picture theater; the projector; the conduct of film exhibiting; methods of coloring films; talking pictures, etc.

By

John B. Rathbun

Associate Editor Motography, Chicago; Instructor of Machine Design, Chicago Technical College; Author of technical books specializing various subjects.

Published by

Charles C. Thompson Company

Chicago, U. S. A.

1914

Special Arrangement with

Electricity Magazine Corporation, Chicago

Motion Picture Making and Exhibiting

Charles C. Thompson Co.

PREFACE.

Within a little more than ten years, the motion picture show has become one of the world's most popular forms of entertainment, and, from a commercial standpoint, one of the most profitable. In the United States alone there are over 15,000 theaters that are devoted to this form of entertainment, that in turn gives employment to one quarter of a million people. From the little "store show" of ten years ago, that eked out an existence with the aid of a shooting gallery and tin type department, the modern picture theater rivals the largest of "legitimate" theaters, both in attendance and equipment.

Aside from its prominence as amusement feature, the motion picture fills a place that has never been reached by the theater; that is, its ability to instruct as well as entertain. Its extended use in educational institutions, and in the proceedings of learned societies has proved its value as an instructor for it presents the most abstruse and difficult subjects in a way that appeals to the most indifferent mind. It has unfolded the beauties of literature to those who have lacked the inclination to read for themselves, and has taken the student through faraway lands that he could never have witnessed otherwise. Little wonder that the pictures have become an established institution among all classes of people.

The great interest aroused among both show patrons and prospective exhibitors in regard to the principles and practice of motion picture making and exhibiting has been responsible for the publication of this little book. Following the general treatment of the subject will be found data that will be of use to the operator and present exhibitor. This was compiled from the files of the trade journal "MOTOGRAPHY" which extend over a period of five years.

It has been the endeavor of the author to lead the reader through the subject in a systematic man-

ner, starting with elementary principles of motion photography, through the process of taking and making the picture, and finishing with the projection of the completed picture on the screen. The chapters devoted to the taking of the pictures, a subject probably of most interest to the lay mind, have been made as complete as possible and are illustrated by views taken around the studios of well known film producers.

TABLE OF CONTENTS.

CHAPTER I.

THE PRINCIPLES OF MOTOGRAPHY.

The conception of motion is purely a comparative process. When a person views an object in uniform motion, he really makes note of the successive positions of the object in regard to some fixed or stationary point in the scene. Because of the rapidity with which he makes these comparisons, he has no remembrance of any particular position and therefore the individual impressions gradually fade into one, giving him an idea of continuous progress. The fixed point that is used for the comparisons may either be an object in the scene or the limiting edges of his field of view. If he observes a simple moving object such as a ball, against a blank background, and followed it in such a way that it always occupied the center of his line of sight, he would receive no idea of motion. If a stationary post were placed behind the moving ball, he would at once unconsciously start measuring its successive positions in regard to the post.

When a single snap-shot photograph is taken of an object in motion, the picture will reveal the attitude and position of the object at the instant of exposure. If a second picture were taken immediately after the first, it would show the position at the second instant, and so on. If a series of such pictures were examined, one after the other in the ordinary way, the progress of the object would be seen, but without any suggestion of motion.

Should the series of pictures be presented to view so rapidly, that the eye would not have time to view and analyze each of the pictures separately, the conditions mentioned in the first paragraph would be reproduced, resulting in the sensation of motion. This illusion depends principally on what is known as "persistence of vision," or in other words, upon the time required for the optic nerve to transmit a visual message from the eye

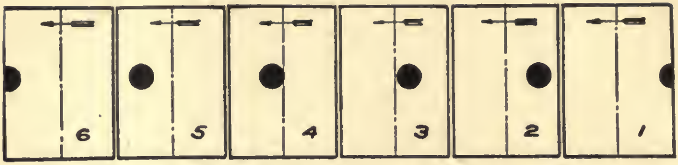


Fig. 1.—Six successive views of a ball passing across a picture. The reference line occupies the same position on each picture.

to the brain. This delay in the transmission of the image results in a continued impression, equal in length, to the time required to pass from the retina to the brain. Thus the brain continues or "persists" in seeing an object after it has passed entirely out of the field of view.

While this time is only 1/24 of a second in the average person, it is long enough to allow a machine to substitute a second picture while the brain is still recording the first. As the sensation of the first view fades away it is immediately succeeded by the second without a perceptible lapse of time, giving the impression of a single picture. As the first picture becomes fainter, the second continues to increase in brightness, and finally obliterates all previous positions of the object. A common example of this property of visual persistence may be had in view-

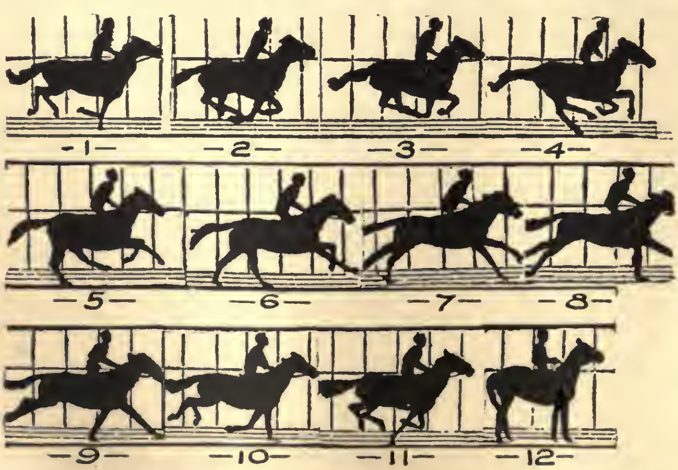


Fig. 2.—Twelve successive attitudes of a horse taken by Muybridge. When passed rapidly before the eyes the pictures give the impression of motion.

ing a flash of lightning. To the observer, the flash appears to last 1/24 of a second, or more, while the flash actually lasted less than .0001 second.

In motion picture work advantage is taken of this property of sight, the successive pictures being thrown on the screen so rapidly that the eye construes the succession as continuous motion. When the shutter of the projector is opened for about 1/32 of a second, the impression is started. This view is now shut off quickly, and a second view is moved into the field of the lens

Fig. 3.—An early type of disc machine. The pictures are illuminated in succession by a narrow beam of light.

which in turn is thrown on the screen before the impression of the first has died away. In practice this operation is repeated at the rate of sixteen pictures per second. The illusion is greatly accentuated by the stationary objects in the picture and by the edge of the screen which has a fixed relation in regard to the spectator.

The twelve pictures shown by Fig. 2 illustrate the principles of the motion picture, each picture in the figure showing the position assumed by the horse at the particular instant at which the picture was taken. They are reproductions of a series of instantaneous photographs taken by Edward Muybridge in 1870, and are considered to be the first motion pictures ever taken of a living subject by photographic methods. When passed

rapidly and intermittently before the eye in their proper order, the horse moves its legs in a life like manner and the jockey bounces up and down on its back.

THE ZOETROPE.

The little "whirligig," known as the "Zoetrope," was the first motion picture machine to be placed on the market, and dates from a period previous to 1850. It was originally intended as a toy for children, and probably for this reason did not awaken much interest in the

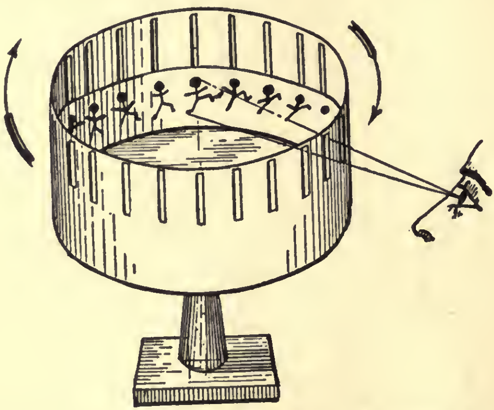


Fig. 4.—Toy Zoetrope, showing the arrangement of the pictures and slots.

possibilities of the moving picture at the time of its inception. The little device contains all of the parts characteristic of the modern projectors, or their equivalent, and performs the cycle of operations in the same way and sequence described in the foregoing paragraphs.

It consists of a hollow pasteboard cylinder mounted on a vertical spindle on which it can be rotated rapidly in a horizontal plane. Equally spaced vertical slots are cut in the side of the pasteboard cylinder which extend to a point about half way from the bottom. The pictures, which are printed on strips of cardboard, are merely outline drawings showing simple objects in ten or twelve successive positions, and are spaced to correspond with the spacing of the slots in the side of the box. The picture strips are placed inside and near the bottom of the box with the picture side of the strips facing the interior

so that they can be viewed by looking through the slots from the outside of the cylinder.

When the Zoetrope is revolved rapidly, the slots and wall spaces alternately expose a picture to view and cut it off in the same way that the shutter of a modern projector acts on a film, so that the observer receives the impression of motion from the succession of pictures. As the pictures and slots advance in opposite directions, being on opposite sides of the cylinder, the action of the slots is very rapid, the cutting speed being twice that of the peripheral speed of the box.

THE EXPERIMENTS OF MUYBRIDGE.

The progress of the motion picture was hampered at all stages of its history by the lack of suitable photograpic materials, and it was not until 1870 that dry plates could be obtained that were fast enough to record exposures of less than 1/20 of a second. The cameras of that time were naturally not adapted for the rapid transfer of the exposed and unexposed plates, and consequently the design of the camera required complete revision before it could be used for motion pictures.

In 1870, an Englishman, Edward Muybridge, conceived the idea of taking a series of photographs of moving objects by means of a number of independent cameras, spaced equally along the path of motion. The shutters of the cameras were to be arranged so that the subject made the exposure by contact with the shutter triggers as it passed in front of the lens. Muybridge finally succeeded in interesting Governor Stanford of California, who financed the proceeding, principally we judge, because of the opportunity that the pictures offered in studying the action of his race horses. The result of his work is shown in Fig. 2.

On one side of Stanford's exercise track, Muybridge erected a white-washed high board fence for the purpose of throwing the horse in brilliant silhouette, for with the dry plates of that day it was useless to attempt detail with the short exposures that he intended to use. Across the track, and opposite to the fence, were placed twenty-four separate cameras, spaced at equal intervals. A string from the shutter of each camera was stretched across the track to the fence so that the horse would

strike each string in passing and thus snap the shutter when it was exactly in front of the lens. The horse in passing was thus photographed twenty-four times.

As the pictures were taken primarily for the purpose of studying the attitudes of the horse in the different stages of its progress, the fence was divided into panels equal in width to the spacing of the cameras. Each panel was numbered so that the pictures could be identified in regard to the positions of the horse. These pictures

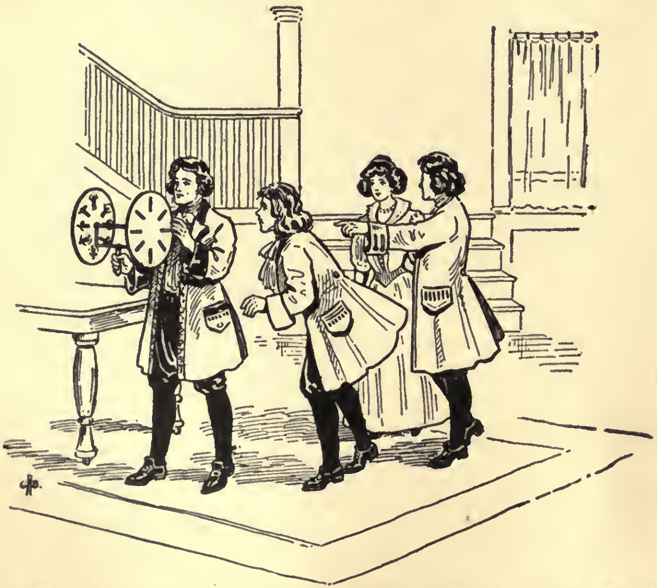


Fig. 4-a.—A double disc machine. One disc contains the pictures, and the other the slots. As the discs revolve in opposite directions, the action is similar to that of the Zoetrope.

created considerable comment at the time, particularly among artists, in regard to the unsuspected muscular action and attitudes of the trotting horse, and settled conclusively all disputes arising from the criticisms of Remington's and Messonier's paintings.

The pictures were afterwards projected on a screen by means of a modified zoetrope wheel, whereupon the peculiar positions were resolved into the natural and continuous motion of the animal. These pictures, while

successful in delineating the motions of the limbs and muscles, had a very serious fault which was due to the fact that the image of the horse did not progress across and pass off the screen, but remained prancing up and down in the center of the picture. This was the result of taking the individual pictures at the time when the horse was exactly in front of the cameras instead of from a single stationary view point as with the modern motion camera. An effect similar to that of the Muybridge pictures would be obtained by following the horse with a camera in an automobile.

While these experiments paved the way to future success, the Muybridge system was out of the question for practical work, for not only were the pictures all broadside views, but 16,000 cameras would be required for a commercial 1,000-foot reel.

THE CELLULOID FILM.

The invention of the celluloid film by Eastman was really the greatest single step in the development of the motion-picture machine, for the chief trouble experienced by the earlier experimenters was due to the awkward and complicated mechanism used to shift the inflexible and fragile glass plates. In addition to the mechanical troubles, the enormous bulk of the dry plates made the continuous operation of the machine almost impossible, and required in addition a considerable amount of storage room. The flexible celluloid film introduced by Eastman made it a simple matter to feed a great number of pictures at an exactly uniform speed, and also made it possible to store a large number of photographs in a small space.

In the modern film the 16,000 photographs on 1,000 feet of film makes a roll only 10 inches in diameter and 1⅜ inches thick. To accommodate the same number of photographs on a glass dry plate would require an area of approximately 82 square feet, which, when put into practical use in a single plate, would make a strip one foot wide and 82 feet long. Subdividing the glass into 82 plates of one square foot area would require a very complicated mechanism and careful manipulation to secure the perfect centering of all the plates in the projector.

As soon as the celluloid film appeared upon the market, the principal difficulties in building a machine were removed and work was started immediately by Edison

Fig. 4-b.—A series of motion pictures arranged on a glass dry plate. The machine projecting these pictures moves the plate up and down and shifts from one row to the next as soon as the last picture in the row is projected.

on his "Kinetoscope." This was the first commercial machine to employ photographs in a continuous strip.

In the Kinetoscope and in modern machines the film is in the form of a long strip. The individual pho-

tographs run down the center of the celluloid ribbon, edge to edge, the top of one picture coming directly on the bottom edge of the other. The strip is run through the projector in front of the lens like a belt and as soon as each picture is centered in the correct position by the driving mechanism, a flash of light is sent through the transparency, projecting the picture on the screen. As the position of the moving object of the film varies

Fig. 4-c.—A modern celluloid film, showing the arrangement of the pictures and the sprocket holes, full size.

Fig. 4-d.—A full sized reproduction of the original biograph film. This film is much larger than those in use today and has a very crude form of perforation.

slightly on each picture, the rapid succession of pictures thrown gives the spectator the impression of motion.

EDISON'S KINETOSCOPE.

While Edison had done a considerable amount of work in developing the motion-picture machine before the advent of the celluloid film, he realized that a commercial success was impossible with glass plates, and

therefore delayed serious work on the problem until the celluloid film was announced as a success in the ordinary photographic processes. Shortly after this, his first machine the "Kinetoscope," made its appearance at the Chicago World's Fair in 1893.

The original Kinetoscope did not project the pictures on a screen, but exhibited them directly through a magnifying glass arranged in a peep hole in the side of the cabinet containing the mechanism. On dropping a coin into the slot, the lights were turned on automatically, and the observer at the peep hole saw a simple series of pictures that ran about thirty seconds. The pictures ran with such rapidity that they appeared in the most life-like manner to the wondering spectator, but as the show

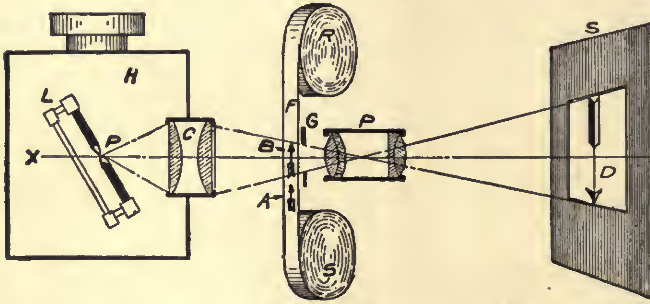


Fig. 5.—The optical system of the motion picture projector.

was short and represented little more than the old, well-known zoetrope, they did not arouse much enthusiasm.

The Kinetoscope contained about 40 feet of film in the form of a continuous band or belt. The band was wound around four or five sets of pulleys in parallel strands, so that the film could be placed in a small portable cabinet. At the top of the Kinetoscope the film was taken over two large wheels in a horizontal direction, and was passed between a magnifying glass and a small incandescent light so that the images on the film could be seen through the glass. A circular rotating disc having a radial slot was placed in front of the magnifying glass, and was arranged so that the positions of the slot and a picture registered when the picture was in the proper position in regard to the spectator. When the picture was either approaching or receding from the

field of the lens, it was covered by the solid sector of the disc.

This shutter rotated continuously in a direction opposite to that of the film, and made one complete revolution during the time taken to pass each picture across the field. The film traveled continuously in a fixed relation to the position of the slot in the shutter, this relation being maintained by a set of sprocket wheels whose teeth engaged with perforations in the edge of the film. By means of gears the film and revolving shutter were driven as one unit.

The Kinetoscope differed from the machine of today in having a continuously moving film instead of the inter-

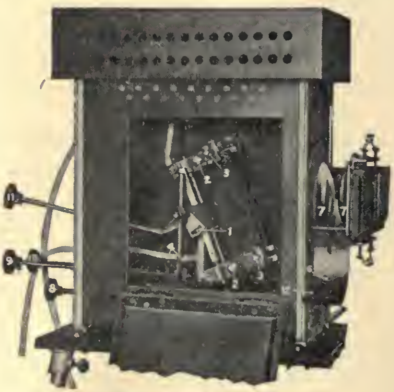


Fig. 6.—The lamp house, showing the lamp and condenser lens.

Fig. 9.—The disc shutter. Three blades.

mittent movement used in the modern machine which stops the film momentarily when an image comes between the lens and the light. The intermittent feed was found necessary in the projector for the reason that the high speed of the shutter in the continuous machine did not permit of sufficient illumination to project a strong, bright image on the screen.

In its optical system or arrangement of the lenses and light, the moving picture machine greatly resembles the magic lantern, or stereopticon. Like the stereopticon, the projector has a small cabinet called the "lamp house" which contains the light, a condensing lens that concentrates the light upon the small area of the

picture, and an objective lens that receives the impression of the illuminated image on the film and projects it upon the screen. These three elements exist in both machines, and are arranged in the same relation.

The film feeding mechanism, which is independent of the optical system, brings forward a small length of the film, equal in length to the height of the picture, and holds it firmly in position while the light is being admitted by the shutter. After the picture has been shown for a sufficient length of time, and after the shutter is again closed, another length of film is fed, and so on. It is absolutely necessary that the pictures be held in exactly the same place on the screen, so that the stationary portions will fall exactly in the same place. If there is the slightest variation in this respect the pictures will jump, or flutter rapidly, as the film passes through the gate, causing a very disagreeable effect in the eyes of the spectator.

This requires a very accurate mechanical movement, for a variation of 1/100 of an inch in the position of the film will cause a movement perhaps 240 times as great on the screen, or will cause the image to vary by 2.4 inches in position. After being pulled into the exact position, the film must be held so rigidly that no vibration will affect its centering. The device that turns on and cuts off the light must be so adjusted that no light passes through the film except when it is stationary in the gate.

In all commercial machines, the relation between the feeding mechanism and the film is maintained by the sprocket teeth of the driving gear and the perforations on the edge of the film, each perforation occupying a definite position in regard to the pictures. When the film is placed in mesh with the sprockets and one picture is in the correct position when the shutter opens, it is evident that each successive picture will come to rest at the same place with an equal turning movement of the feeding sprocket, as the perforations are equally spaced. As the shutter revolves at a fixed ratio with the sprockets, each picture will be exposed in the gate, when exactly central with the screen.

While it may seem a simple matter to devise a machine to perform this operation, it is really quite difficult, as the slightest error in the feed will be greatly

magnified on the screen. Any wear of the parts causing lost motion, or any lack of adjustment will cause serious flickering due to uncertainty of the film position. Many years of experiment were necessary before the correct materials were found to resist the enormous wear and tear of the moving parts, and before the design was worked out so that the proper adjustments could be made. The improvement made in projectors during the last few

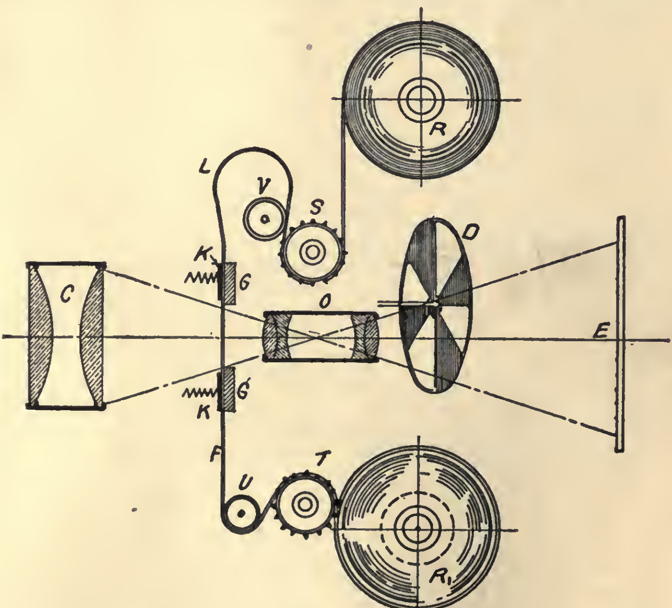


Fig. 7.—Diagrammatic view of the components of the motion head, showing the position of the disc shutter.

years in respect to jumping and flickering is evident to anyone who has long been a patron of the motion picture show.

THE OPTICAL SYSTEM.

By the term "optical system" we mean the parts of the projector that generate the light and project the image on the screen, the lamp, the condenser lens, the film, the objective lens, and the screen are the principal parts of this system. In Fig. 5, the lamp *L*, and the con-

denser *C* are contained in the cabinet or lamp house *H*. The condenser lens *C* receives the widely dispersed light rays given by the lamp *L*, and concentrates them in a small area on the film *F*, greatly increasing the brilliancy of the illumination on the film. The rays that formerly occupied the entire area of the condenser are now reduced to a diameter equal to the arrow *B*, and since the same amount of light now occupies a much smaller area, the intensity or brightness is greatly increased.

As the converging rays pass through the transparent film *F*, they are broken up by the image on the surface, the darker parts of the image obstructing more light than

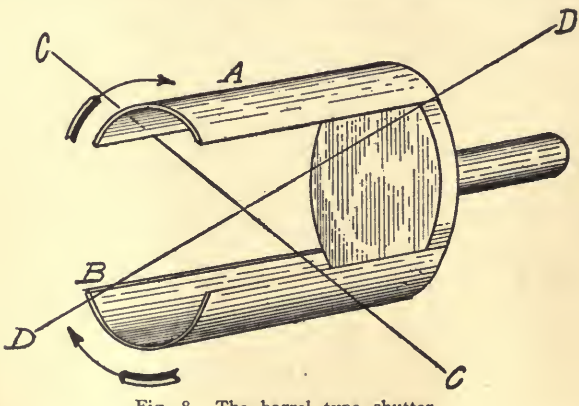


Fig. 8.—The barrel type shutter.

the more transparent portions and as a result, cause the values of the different portions to be recorded on the screen in proportion to their density. If the arrow *B* on the film, for example, were perfectly black, it would obstruct all of the light in its path so that its shadow would be produced at *D*, on the screen. In the same way the outlines of the lighter objects on the same film would be shown in proportion to their density.

In passing from the film to the objective lens *P*, the converging lines of light cross the optical center line (*X-X*) at a point midway between the two lenses that form the objective *P*. From the point of intersection, the lines of light again spread out or diverge, but in such a way that the lines that were formerly at the

top of the image on the film are now thrown on the bottom of the screen. The reason of the inversion of the image on the film will be seen if the line reaching from the top of the arrow *B* is followed to the bottom of the screen, and the lower end of the arrow *D*. Since the angle of the light rays reaching from *B* to the center of *P* is the same as that reaching from *P* to *D* it is evident that *D* is as much larger than *P* as it is farther from the point of intersection. It will be noted that the center of the condenser is on the same center line as the center of the objective lens.

It is evident that the film must stop centrally on the center line of the lens *X-X* if the image is to be equally distributed on the screen *S*, without distortion. The film mechanism is arranged so that each picture is centered on the optical center line at the moment that the shutter is opened. To prevent light from passing around the edges of the picture on the film and to steady the film, a small plate with an opening equal to the size of the picture is placed centrally on the line *X-X* at *G*. This is known as the film "gate."

As the area of the condenser lens is much less than the superficial area of the sphere of light surrounding the arc *P*, about 90 per cent of the light is lost by absorbtion by the walls of the lamp house, hence only 10 per cent is effective at the condenser lens for projection. In the future the projector will, no doubt, be provided with a reflector that will concentrate and throw the light on the condenser where it belongs. When this is accomplished, it will be possible to secure brighter pictures with less expenditure of current.

THE MOTION HEAD.

The part of the projector that contains the film mechanism is known as the "motion head" and is entirely independent of the optical system except that the head sometimes affords a support for the objective lens. In the casing of the "head" is the shutter, the intermittent film feed, the two film magazines, and the safety shutter. At the side of the housing is the operating crank for driving the machine.

The principal elements of the motion head are shown in their usual relation by Fig. 7. The light from the

condenser *C* passes through the film *F*, the gate *G*, the objective lens *O*, and the shutter *D* to the screen at *E*. The sprocket *S* engages with the perforations in the film and draws the fresh film from the reel *R*. A roller *V* keeps the film in engagement with the sprocket and controls a loose loop *L* known as the "takeup" loop. This loop prevents excessive strain from being thrown into the film by the intermittent feed.

From the loop, the film is drawn into the film gate *G* where it is straightened out and put under slight tension by the friction of the tension plate *K*. The film is

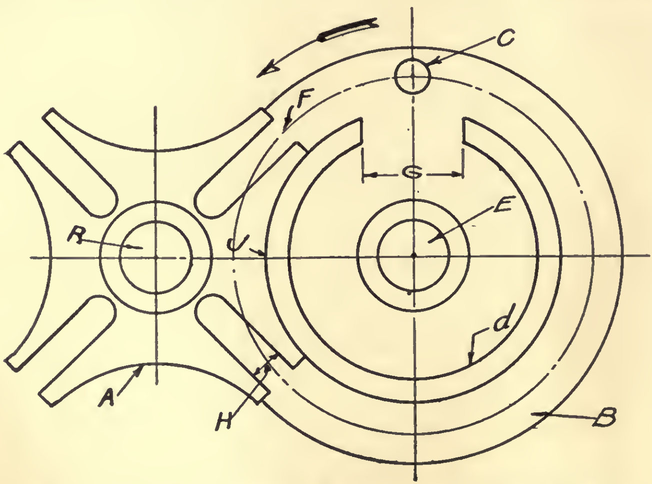


Fig. 10.—The Geneva intermittent movement used for feeding the film.

drawn through the gate by the sprocket *T* which is driven by the intermittent movement, the film being kept in contact with the sprocket by the roller *U*. From the sprocket the film is wound on the reel *R*. The light passing through the film is periodically interrupted by the shutter *D* at the time when the film is being pulled through the gate.

THE SHUTTER.

In nearly all machines the film remains stationary in the gate for four-fifths of the one-sixteenth second taken to pass one picture. One fifth of the total time is taken for the shifting of the film, and therefore repre-

sents the time the lens would be covered by the shutter, were the action of the shutter instantaneous. Since a considerable length of time is required for the shutter edge to traverse the width of the light beam, the actual period of darkness is greater than the theoretical time, which of course reduces the value of the screen illumination. To obtain a maximum shutter opening and illumination it is evident that the shutter should close promptly and open promptly at the instant that the picture comes to rest in the gate and when it again starts to move out of the field of the lens.

The problem of quick shutter action has led to the development of a multitude of devices, only three of which have survived the tests of practical usage. All of the three shutters, the *disc, barrel* type, and *multiple disc* types, are rotary and revolve continuously in fixed relation to the movement of the film feed mechanism.

The barrel shutter used in some machines now on the market consists of two parallel blades, that revolve together about a common center, the blades being segments of the surface of a cylinder whose center coincides with the center of rotation as shown by Fig. 8. When the blades *A* and *B* are in the position shown, the converging light rays *C-C* and *D-D* pass between them to the screen. On rotating the cylinder in the direction shown by the arrows, the blade *A* starts to cut off the upper rays *C-C,* and the blade *B* cuts upward through the lower rays *D-D,* thus cutting the beam at double the peripheral speed of the drum. When the edges of *A* and *B* are opposite one another on a horizontal line, the light is completely interrupted. This action occurs twice per revolution, making it possible to run the shutter at half the speed of the film feed or at the rate of one revolution for two pictures.

As the blades work from both sides of the ray at the same time, the cutting action is very rapid, being twice that of a single edge that passes through the ray in the ordinary manner. When the drum is revolved at the same speed as the film shift mechanism, the light is admitted to the lens and cut-off twice per picture, which makes the interruption less apparent and reduces the flicker that is in evidence at the lower speed of one interruption per picture. Because of the high cutting

speed that results in a small cylinder diameter, the barrel type of shutter is placed inside of the motion head casing between the film and the objective lens, and centered on the apex of the converging light rays.

The disc shutter, the most commonly used type, is simply a circular sheet metal disc in which two or more sector shaped windows or openings are cut, and unlike the barrel type, its edges enter one side of the beam only, and from there pass entirely across the beam. As the cutting speed of a single opening is only half that of the barrel type shutter, the disc is necessarily of larger diameter

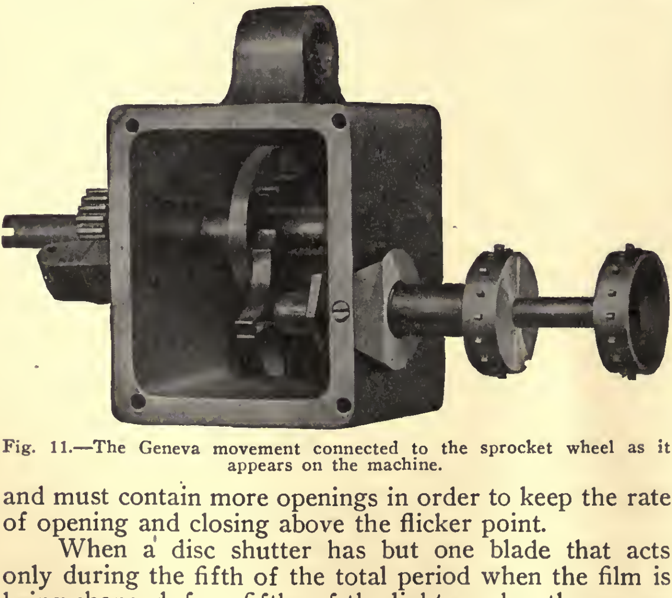


Fig. 11.—The Geneva movement connected to the sprocket wheel as it appears on the machine.

and must contain more openings in order to keep the rate of opening and closing above the flicker point.

When a disc shutter has but one blade that acts only during the fifth of the total period when the film is being changed, four-fifths of the light reaches the screen. As this period of exposure is comparatively long, the single blade is not desirable. With a two-blade shutter that is arranged so that each blade covers the lens during one fifth of the total picture shift, twice as many impulses are obtained, but the light is reduced by one fifth more, making the screen illumination only three-fifths of the maximum. The number of interruptions given by a two-blade disc shutter are equal to those of the barrel type running at the same speed.

In practice the disc shutter is usually supplied with three openings and blades, each opening being approximately one-sixth of the total area of the disc. Fig. 9 shows the arrangement of the three bladed disc. Double discs have been used in some cases to obtain the quick opening and closing characteristics of the barrel shutter, the discs being revolved in opposite directions so that the light beam is cut in two places at the same time. This of course doubles the cutting speed and materially reduces the flicker incident to a single blade traveling at a low speed.

INTERMITTENT MOVEMENTS.

The intermittent motion required for shifting the film through the gate converts the continuous rotary motion of the crank into a series of short rectilinear movements, each of which is equal to the height of the picture on the film. There are many devices by which this result may be accomplished, but as there are only two of these movements in extended use, we will confine ourselves to a description of these types.

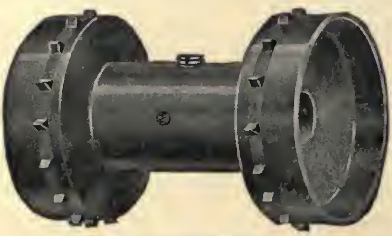


Fig. 12.—Film sprocket.

The "Geneva movement," which is by far the most commonly used type on projectors, possesses nearly all of the desirable qualities of a film feeding mechanism. It starts the film slowly, brings it up to speed without strain, it then brings it to rest at a gradually decreasing rate. During the interval at which the film is at rest in the gate, the device holds it firmly in place without danger of slack or vibration, either of which would cause the image to flicker on the screen.

The movement consists of two parts: the "star," which is fastened to the sprocket shaft, and the "pin" wheel that revolves continuously with the operating crank, the latter element being the driving member.

These parts are shown in elevation by Fig. 10, in which *A* is the star wheel, and *B* is the wheel carrying the pin.

When the wheel *B* is revolved in the direction shown by the arrow, the pin *C* engages with the slot *F* and turns the cross *A* through one-quarter of a revolution, the point of the cross passing through the opening *G* in the retaining ring *D*. After turning through this quarter revolution, the slot arrives at the point *H* and is held rigidly in position by the ring *D* that fits into the concave face *J* of the star wheel.

As the wheel *B* continues to turn, the ring *D* holds the star wheel in position so that it cannot move until the pin *C* completes another revolution, and enters the next slot of the star wheel. In this way the star wheel makes one quarter of a revolution for every complete revolution of the pin wheel *B*, or one revolution for four of the wheel *B*. As will be seen from the figure, the starting of the movement is slow, as the pin enters the slot in a direction nearly parallel to the groove. As the pin approaches the center line of the wheels, the speed of the star wheel is increased rapidly but smoothly as the effective radius of the pin increases at the expense of that of the star wheel.

From this point on, the rapidity of movement gradually decreases until the pin finally leaves the slot in a direction parallel to the edges. At this point, of course, the star comes to a stop, and the ring comes into contact with the concave face, holding it firmly in position. The shaft *R* connects with the sprocket wheels, and the shaft *E* with the operating crank. The opening *G* in the retaining ring is directly below the pin *C*.

By employing two pins instead of one, the star wheel may be made to turn one half revolution instead of one quarter per revolution of the pin wheel, as the two pins will engage in the slots twice as often as the single pin. The addition of the second pin necessitates no further changes in the gear except that a second opening *G* must be supplied under that pin. The ratio between the periods of rest and motion in the star wheel depends entirely upon the relation of the diameters of the two wheels.

The claw mechanism, while seldom used in projector construction, is used extensively in the cameras used for

taking moving pictures. In the claw motion, a finger works directly on the film perforations instead of acting through a sprocket wheel. The "claw," driven by a suitable crank or cam, moves forward, engages with a set of perforations in the film, and then moves down, carrying the film with it through a distance equal to the height of the picture. At the end of the stroke, the claws dis-

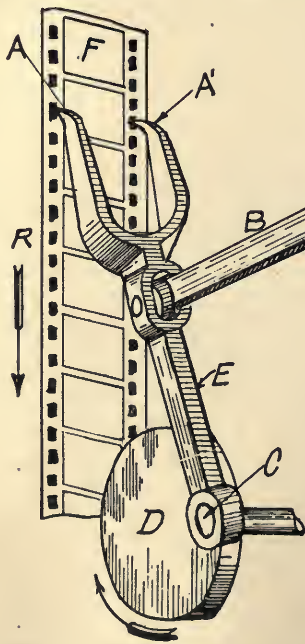


Fig. 13.—The claw type of intermittent motion, used principally on motion picture cameras.

engage from the film and return to the starting point ready to pull down the next section of film.

A typical example of this type of feed mechanism is shown by Fig. 13, in which F is the film, A and A^1 the claws, E the connecting rod and C the crank. When the claws are in the position shown, they are in engagement with perforations in the film F. As the crank continues to turn in the direction of the arrow, the claw points are carried down by the rods E and pulling the film with them in the direction of the arrow R. At the bot-

tom of the stroke, the crank pin moves to the left and the claws to the right, pulling them out of the perforations and free from the film. The claws remain a short distance from the film until the crank again reaches the top of the stroke and moves to the right, moving the claws again into contact with the film perforations.

The claw rods are prevented from moving with the crank in a horizontal direction by means of the radius rod *B* which extends from a stationary portion of the machine. The radius rod is pivoted at both ends, permitting the claw rods to oscillate about the joints.

THE FILM GATE.

The principal function of the film gate is to steady and flatten the film so that it will not move edgewise in the gate during the period of projection, or cause distortion of the image through the curling of the film. It also acts as a check to the momentum of the film so that it will not "follow" nor buckle when the film and reels are brought suddenly to rest. The opening or aperture in the gate is slightly smaller than the picture on the film, and prevents the light from escaping around the edges of the picture.

In effect, the gate is a form of friction brake that acts directly on the film, the frictional drag acting against the pull of the feed sprocket so that the film is kept taut and straight at all times whether moving or stationary. To prevent sidewise motion, or to prevent the film from assuming a diagonal position in front of the aperture, the plate is provided with two side rails which act as guides, the distance between the rails being just enough to clear the width of the film and no more. Friction is produced by the action of springs that press a plate on the back of the film, forcing the front face against the main gate platen. The tension on the film may be varied to compensate for the wear on the surfaces by increasing or decreasing the spring tension.

When the shutter and film shift mechanism are not operating in the proper relation to the gate, so that the picture is not exactly in the center when the shutter opens, the picture is said to be "out of frame." When this condition exists, the top of the picture no longer coincides with the top of the illuminated area on the

screen, with the result that parts of two adjacent pictures are thrown on the screen simultaneously. To avoid stopping the machine for readjustment, all commercial machines are provided with devices by which the proper relation may be re-established by the operator while turning the crank. This operation is known as "framing up."

Framing the picture may be accomplished by four different methods, all of which depend upon changing the relative positions of the gate, lens and film sprocket. Moving the lens and gate up or down will bring the pic-

Fig. 14.—A reel of film ready for projection.

ture in frame, advancing or retarding the film shaft with the lens and gate stationary will give the same result. Increasing or decreasing the amount of slack in the film loop will change the relation of the film and film gate, and is therefore effective in framing the picture.

No matter what system is used, the control lever that frames the picture is invariably capable of a film displacement equal to the height of one picture, or even more. When the operator looks at the screen and discovers that the picture is out of frame, a slight movement of the framing lever in one direction or the other will raise or lower the picture in the gate to the correct position.

THE SAFETY SHUTTER.

The light concentrating effect of the condenser lens produces a very high temperature in the film gate, much higher than the ignition temperature of the celluloid film,

and for this reason the film must be kept moving rapidly in order to prevent the light rays from setting it on fire. Should the film stop for even a few seconds in the gate, it will burst into flames. Any accident or neglect that will cause the film to stop or slow up, such as film breakage, or failure to turn the machine at the correct speed,

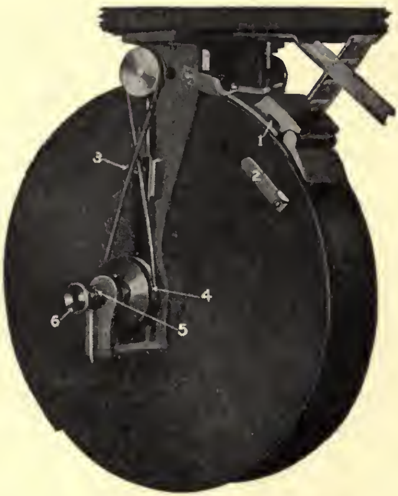


Fig. 15.—A belt-driven take-up reel. The reel is driven by the belt (3) that passes over the pulley (4). The friction adjustment is made by the thumb screw (6).

might cause fire unless some device is provided that will automatically cut off the light from the condenser as soon as the trouble occurs.

A device of this nature, known as a "safety shutter," is provided in some form on all projectors, although in the majority of cases it is effective only in cutting off the light when the machine slows down beyond a certain point. A trustworthy safety shutter acting automatically when the film stops, and not merely when the machine stops, seems not to have been developed up to the present time. The many conflicting conditions that must be met with such a device makes the design of a fool-proof safety shutter a difficult proposition, and from the failures recorded it would seem that the only solution of the problem is non-inflammable film.

In practically all projectors, the safety shutter consists of a metal gate placed between the condenser and the film. A centrifugal type of governor driven by the motion of the operating crank is connected to the sliding gate in such a way that any decrease in the cranking speed slides the gate between the film and light. The governor consists of a vertical spindle on which are pivoted two small balls or weights. When the spindle is revolved, the weights tend to assume a horizontal position, and in swinging up from the vertical plane, they move a rod that acts on the safety shutter. A spring that acts on the revolving weights places a limit on the allowable shutter travel for any given speed, hence the rise of the weights is roughly proportional to the speed of the crank and spindle.

To reduce the danger of having flame spread back into the feed reel, it is customary to enclose all of the film, except that immediately in front of the lens, in a fire-proof metal casing. A metallic tube, placed around the film issuing from the reels, smothers the flame before it travels more than an inch, with the result that only a few pictures are burned in the vicinity of the aperture. This, however, does not prevent possible interruption of the show, nor does it insure complete protection against the loss of the reel of film, for it is possible for the operator to neglect closing the access doors of the magazine.

FEED AND TAKE-UP REELS.

The reels upon which the film is wound are invariably encased in metal shields called "magazines," which are directly attached to the motion head. Circular doors located in the sides of the magazine allow the operator to insert and remove the reels of film. A spindle is provided on which the reel turns freely as the film is wound and unwound by the action of the feeding mechanism.

The feed reel is simply a spool having two metal flanges about ten inches in diameter, and a core that is provided with a spring clip for holding the end of the film. Fig. 14, shows a reel of film ready for mounting in the projector.

The take-up reel is the same as the feed, except that is is mechanically driven through a belt by the operating crank instead of by the pull of the intermittent feed

mechanism. As the take-up reel receives the film from the feed reel, the roll of film becomes larger and larger in diameter, and therefore revolves more slowly than the feed reel from which the film is unwound. To compensate for this difference in speed, it is necessary to have the take-up reel slip in regard to the feed reel to prevent excessive strain on the delicate film. This is accomplished in some machines by means of friction discs

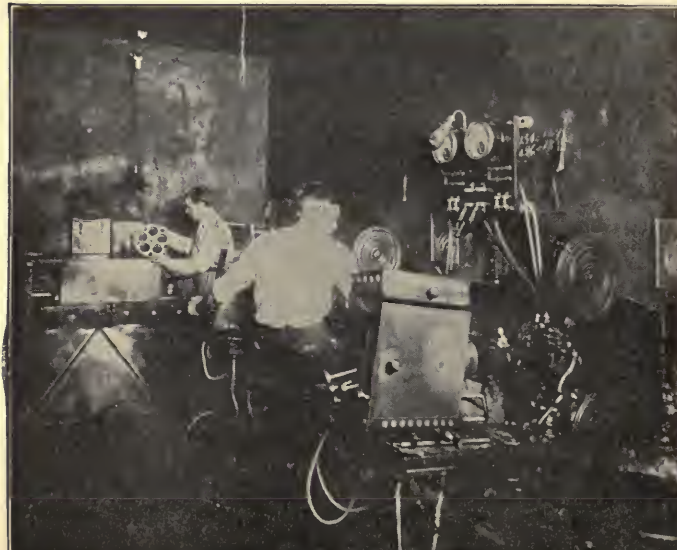


Fig. 16.—View in the operating booth of a motion picture theater, with the projector in the foreground. At the rear, one of the operators is rewinding a film.

attached to the reel drive adjusted so that it is possible to apply only enough power to turn the reel, and not enough to snap the film. In other machines the tension of the belt is adjusted so that it will slip when too much pull is exerted on the film. Since all friction devices wear in time and cause trouble by getting out of adjustment it would seem that a differential gear, such as used on spinning machinery, could be applied with advantage to the projector. The action of the differential insures

constant tension on the strand at all times, and is not influenced by wear.

REWINDING THE FILM.

After the film has been projected, and is completely wound on the take-up reel, it is necessary to rewind it on the feed reel so that the pictures will again go through the projector in the proper order. If the film were fed into the machine directly from the take-up reel the pictures would appear reversed upon the screen. Rewinding may either be accomplished directly on the projector, or by a separate rewinding machine which is generally driven by a motor. In many states a rewinding machine is necessary because of the laws that prohibit rewinding in the operating booth.

When the film is to be rewound on the projector, the operating crank is arranged so that the speed of rewind is much greater than the ordinary projecting speed. This makes it possible to rewind a film in two minutes that took twenty to project. The rewind speed may be obtained either by shifting a lever on the machine, or by transferring the crank to an independent rewind shaft.

MOTOR DRIVE FOR PROJECTORS.

Motor driven projectors have many advantages but are prohibited in practically all of the larger cities as the use of the motor makes it possible for the operator to leave the machine when in operation. If the motor should stop, or the film break during his absence the chances for a disastrous fire would be greatly increased over the ordinary method of operation. Practically the only remedy for this condition would be a spring controlled switch that would cut out the light as soon as the operator removed his hand from the machine, making it impossible for him to leave the booth with the machine running. As it is difficult to construct a switch so that it cannot be tied or braced in the running position by the operator, the use of the motor has so far been condemned. Some progress in designing automatic stops for motor driven projectors has been made, however.

THE SCREEN.

The screen acts simply as a reflector, the function of which is to reflect every image thrown on it by the

projector back into the eyes of the audience. With a screen having a high reflecting value, it is possible to secure bright pictures with a small amount of current in the lamp, which naturally gives a low operating cost. In the attempt to cut down the current consumption of the lamp, and to increase the brilliancy of the screen image, many manufacturers have conducted experiments with different materials such as aluminum, aluminum bronze, and mirrors with ground surfaces for use in building screens. The aluminum has been used both in the metallic form, and in the form of bronze paint which has been applied either on the plaster of the wall or on muslin screens. The mirror screens, while having a high first cost, have proved very efficient.

The selection of a proper screen material is of great importance to the theater owner, both in regard to operating economy, and to the attractiveness of the show. With the usual rates for illuminating current, a mirror screen or aluminum screen will soon pay the difference in first cost over the common muslin or plaster surface. The relative values of the different surfaces are given in the following table, and are expressed in the percentages of reflection that they give in regard to a surface giving total of 100 per cent reflection.

Material.	*Value in Per Cent.*
Polished silver	.92—.93
Mirror, silvered on back	.82—.88
Aluminum, frosted	.60—.65
Plaster walls, white	.35—.40

To prevent the distortion of the image, the screen should always be placed perpendicular to the optical center of the projector. If the screen is tilted out of this position on a horizontal axis, the vertical distances will be shortened with a constant horizontal length. If turned to the right or left, the vertical lengths will remain the same, but the horizontal will be reduced. The distortion will be the greatest at the farther edge of the screen as the distance included between the angle of two adjacent rays is greater at the greater distance. The screen should be given a backward inclination when the projector is pointed down at the screen from a balcony or other elevated position so that the screen is perpendicular to the optical center of the projector.

CHAPTER II.

MAKING THE PICTURE.

In a general way, the process of taking and finishing motion pictures is the same as that followed by the amateur photographer in taking and finishing snap shot pictures. In both cases a "negative" film is obtained by exposing a sensitized strip in a camera which is afterwards developed and printed. This negative is then used in obtaining a "positive" print by allowing light to pass through the image on the negative and onto the positive sensitized film. This reproduces the image but in a reversed form, all of the light portions of the negative being dark on the positive, and vice-versa. Instead of using paper for the positive print as in Kodak photography, the motion picture manufacturer makes his on a celluloid strip that is similar to the negative film. The light of the projector passes through the transparent positive print and traces the image on the screen.

The principal difference between the snap shot and motion picture camera lies in the shutter action and the film feeding mechanism, the action of these parts being practically continuous in the motion picture camera. Externally the latter type of machine resembles a large box camera that has a crank, a film measuring dial, and focusing aperture in addition to the equipment of the hand camera. An exceptionally fast lens is required, the usual lens being an anastigmat with a working aperture of $f/3.5$ to $f/3.0$, while lenses of $f/2.0$ are not uncommon. All of the cameras are provided with adjustable diaphragms similar to those used with view cameras. The focal length of the lens ranges from 2 to 4 inches. The usual focal length, about three inches, gives an angle of view of about twenty degrees. A two-inch focal length gives about thirty degrees. When more field is required in the foreground than is given by the three-inch lens, a lens of shorter focal length is substituted.

Two independent mechanisms, the shutter and the film feeding device, are actuated by the crank in such a manner that the film is fed forward for a new exposure with the shutter closed, and is held stationary while the exposure is being made, the film progressing through the camera by a series of jerks. At each movement the film is fed forward through a distance equal to the height of one

Fig 17.—Motion picture camera and operator ready for action.

picture (¾-inch). As the camera operator continues to crank the machine, the shutter and film movements are repeated over and over again so that a number of pictures are made in a row down the center of the film.

These miniature photographs are placed so close that the top of one coincides with the bottom edge of the picture lying next to it.

To insure accurate spacing, the film in some cases is positively driven through a sprocket wheel that engages with a series of perforations in the edges of the film. In this way a fixed relation is maintained between the shutter and the pictures so that each picture will be in the proper place in the projector on the opening of the shutter. In other cameras the toothed sprocket wheel is supplanted by a reciprocating hooked rod or claw, the points of which engage with the perforations in the edges of the film. In either case the result is the same. The claw points engage with the perforations at the upper end of their stroke, and as the crank revolves they are jerked down suddenly, pulling the film with them through a distance equal to the height of the picture. At the lower end of the stroke a special motion disengages the claws from the perforations and they at once begin their upward travel without moving the film. The claw type of intermittent mechanism as shown in Fig. 13 in Chapter I, is better adapted to the camera than the projector, for in the camera the period of film rest is shorter and the wear due to the claw movement is practically negligible as the film passes through the camera but once.

A revolving shutter of the vane or sector type is generally used which is gear connected with the operating crank. This shutter is simply a circular sheet metal disk with a "V" or sector shaped opening cut in it for the admission of light to the film. As it revolves, this opening comes opposite to the lens intermittently and in fixed relation to the film movement.

The disc shutter is used in nearly all cameras, and is very similar to that used in the projector except for the proportions of the vanes or blades. It is generally placed between the lens and the film. The openings in the shutter are usually adjustable by the use of two discs, or rather half discs, that are mounted on the shutter shaft. When the two halves are exactly over one another the shutter is said to be "half open" as the opening constitutes one half of the total area of the shutter. By sliding one disc over the other, any intermediate proportion of opening may be easily made. The usual exposure is about three-

eighths open. The exposure given with this opening is much longer than would be possible with an ordinary snap shot camera in taking pictures of moving objects,

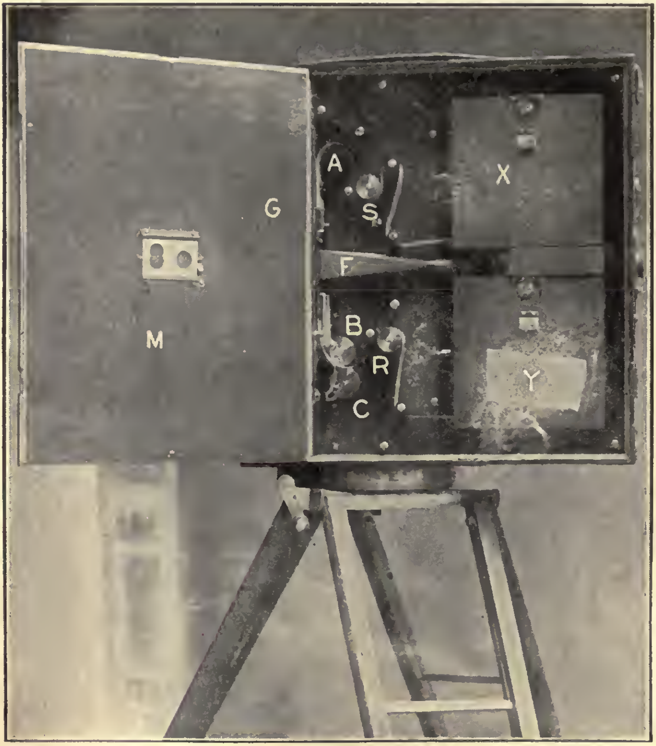


Fig. 18. The interior mechanism of a motion picture camera. *F* is the finder tube extending from the gate *G* to an opening in the back of the camera at *Z*. *C* is the intermittent claw movement. *S* and *R* are the feed and takeup sprockets that form the feed and takeup loops *A* and *B* respectively. *X* and *Y* are the feed and takeup reels. *M* is the access door.

where the slow speed would cause blurring. The effect of blurring in the case of the motion picture is practically negligible, as the objects projected are continually changing on the screen, and as no two pictures lie on the same place the "fuzzy" edge is not noticeable.

Two light-tight film reels are provided inside of the camera for the exposed and unexposed film, the film unwinding from one reel to the other as it moves past the lens. Both reels are accessible to the operator through a door in the side of the camera, and are arranged so that they may be removed or replaced in broad daylight.

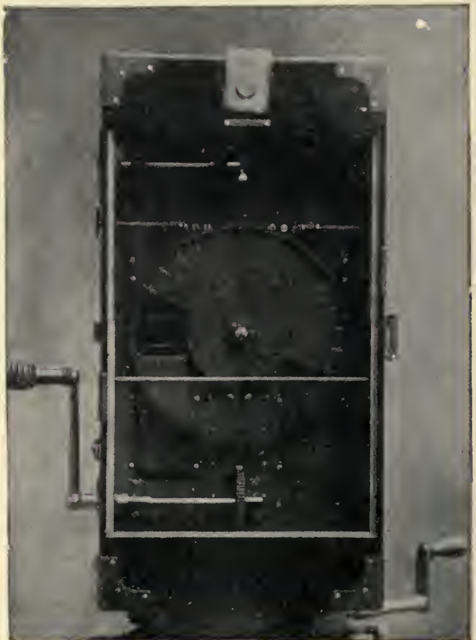


Fig. 19. Front view of a double lens camera, showing the disc shutter and operating crank. The gate will be seen directly under the shutter opening at the right.

The lens, which is mounted centrally in the front face of the camera, is focused by moving it back and fourth in a tube that surrounds the barrel, without the usual bellows of the hand camera.

The loading of a motion picture camera is usually no more difficult than threading the film through a projector or replacing a cartridge in a snap shot camera. The negative film is supplied in two hundred foot lengths, packed in a flat, round tin box thoroughly sealed against

the light. The film is then transferred to the camera film holder by rewinding it around the core of the holder, or by opening the sides and slipping the roll directly on the core. When the film is in place the outer end is slipped through the feed slot ready for threading through the camera.

The film holders are usually light wooden boxes just wide enough to clear the film and large enough to accommodate two hundred feet of film. A spindle on which the film is wound passes through the sides of the holder in bearings; the removal of the side door through which the film is installed allows the spindle to be withdrawn for the purpose of reloading. On the end of the spindle is a slot or keyway that engages with the camera drive.

There is no focusing screen as in the ordinary camera, for it is more convenient to focus the camera on the small portion of the film that passes in front of the lens. The image of the film is viewed through an opening in the side of the camera box. The amount of film that is destroyed by the process of focusing is very small and has no injurious effect on the balance of the film as the reels are enclosed in light-tight cases. A dial that indicates the number of feet of film that has passed through the camera is placed on the side of the box so that the operator can tell exactly how much film is left in the magazine.

In addition to the regular operating crank, a "trick" crank and reversing crank are sometimes provided. When the trick crank is used, only one half of the pictures are taken per second or sometimes only one picture at each movement of the crank. The reversing crank is used in taking pictures in which the objects appear to be running backwards, or in which the actors appear in such feats as jumping out of the water or over high walls. In the latter class of pictures the actor really jumps down from the wall or into the water, but as the motion of the film is reversed in regard to the pictures taken in the previous sections, the subjects move up instead of down.

In some studios, double film cameras are used that carry double lenses and shutters acting in unison, making it possible to take two films at one time. The general make-up of the double camera is the same as the single, the only difference being in the size and interconnections of the driving gear. The lenses are focused separately.

A motion picture camera weighs 25 to 50 pounds, which with several reels of film and a heavy tripod, makes out door picture taking no easy task, especially in military scenes where much shifting about is necessary. Taking a picture means more than merely grinding a crank, and contrary to the general belief requires more than ordinary photographic knowledge. In taking studio pictures the operator must assist the director in keeping the action between two sharply defined boundary lines, must keep him informed as to the length of the remaining film, and must keep accurate account of every motion made during the run of the film. In a way he is also an assistant stage manager.

In taking pictures from aeroplanes or dirigibles, the cameras have, in several instances, been driven by small electric motors instead of by hand. This method was necessary for the reason that the attention of the aviator was, of necessity, concentrated on his controls.

Great care must be exercised by the camera man to have the operating crank turn at a constant number of revolutions per minute so that all of the pictures will be equally exposed, and so that the pictures will have the proper speed when projected on the screen. Pictures that have been taken at a low speed cannot be properly corrected on the screen. The speed of the crank must be uniform throughout the revolution as well, to prevent a jerky projection. Too vigorous cranking will sway the machine from side to side causing a swaying picture on the screen.

FILM AND FILM DIMENSIONS.

The film stock on which the negative is taken is similar in appearance to that used with snap shot cameras, except that the emulsion is much faster and the stock is of a more durable quality. It is 1⅜ inches wide and approximately .006 inch in thickness, of which .005 inch is represented by the celluloid, and .001 inch by the emulsion. The celluloid is manufactured in lengths of 200 feet, the usual length of 1,000 feet being obtained by cementing five of the strips together.

The pictures, which are one inch in width, extend down the center of the strip, leaving two 3-16-inch margins which are occupied by the perforations. Each pic-

ture is three-quarter inch high, measured along the length of the film, making 16 pictures per running foot. As the film is fed through the projector at the rate of 16 pictures per second, its velocity is one foot per second. At this rate a 1,000-foot film will last 1,000 seconds or a little less than twenty minutes.

All makes of film have the same number of perforations or sprocket holes per running foot. The standard punching is four holes per picture on each side of the film, or 64 perforations per foot. Needless to say, the spacing of the holes must be performed with the greatest accuracy in order to have the pictures synchronize with the shutter of the projector and fit the sprocket teeth. Imperfectly spaced sprocket holes cause flickering and jumping and greatly increase the wear of the film. An error of .001 inch in the spacing results in a movement of nearly one-quarter inch on the screen.

The perforation, which is about one-eighth inch in width and one-sixteenth inch high, is of an oblong shape, the smaller ends being slightly rounded. This shape is the result of many experiments conducted for the purpose of discovering the form of perforation that would show the least wear. Circular, triangular, and square perforations were all tried and found wanting; the circular holes would wear to an oval, and the triangular holes would tear out.

In the majority of cases, the films are perforated at the studios after the crude, sensitized stock has been received from the film manufacturer, and shortly before the exposure is made. As the celluloid expands and contracts continuously after its manufacture, because of certain physical changes that take place in its composition, it is best to perforate shortly before the exposure, in order to prevent errors in the spacing from the warping of the film.

In printing the positive film from the negative, the teeth of the sprockets in the printing machine pass through both films, holding them in perfect register, until the proper exposure has been given. This makes the positive print a perfect duplicate of the negative in every respect.

A perforating machine is simply a small automatic punch press, that punches the eight holes opposite each

picture in a single operation, usually in a step by step method. The film is fed by an intermittent mechanical movement, very similar to the camera feed movement. This step by step machine is more accurate, although slower, than the rotary machine used by some manufacturers. The rotary press passes the film through continuously revolving rollers at a rate five or six times greater than the intermittent type.

MANUFACTURE OF CELLULOID FILM.

While celluloid successfully fills all of the requirements of a true photographic base in regard to toughness, transparency, and flexibility, it is objectionable because of its inflammable nature. To overcome this fault, many attempts have been made to substitute other materials for celluloid, but up to the present time all the materials that have been suggested have proved of little value owing to their brittleness. In several of the proposed compounds, the brittleness increases with the age of the film, so that at the end of a few months it is impossible to unwrap the film from the reels without breaking it.

Celluloid is a chemical combination of pyroxlin (gun cotton) and gum camphor. The two constituents are brought into intimate contact through some solvent, such as alcohol. The addition of the camphor solution to the fibrous gun cotton converts it into a transparent gelatinous mass entirely different in appearance from either of the original components.

Gun cotton, the base of celluloid, is made by treating ordinary cotton with nitric and sulphuric acids in nearly equal proportions. During the time the cotton is immersed in the solution it undergoes a complete chemical transformation, but without any apparent change in its physical structure or appearance. When the process is completed the cotton is taken out of the bath and is thoroughly washed in cold water to remove the last traces of the acid. Should any acid remain in the cotton it would effect not only the sensitized emulsion that is applied but would also increase its inflammability. The camphor used in the process is dissolved in just enough alcohol to effect a complete solution of the gum. The alcohol in itself acts simply as a medium for distrib-

uting the camphor through the mass of the cotton and does not have any chemical effect in the reaction.

After the preparation of the camphor solution and gun cotton, alternate layers of the cotton are placed in a tank, each layer being thoroughly sprinkled with the camphor solution. The contents of the tank soon com-

Negative Film. Positive Film.

Fig. 20. Showing the difference between a negative film and the positive print taken from it. It will be noted that the light and dark portions of the negative are reversed on the positive.

bine into a homogeneous mass and the resulting crude celluloid drops to the bottom of the tank in transparent lumps, having much the appearance of amber. Slight variations in this process are made by different firms, some of which comprise a mixture of gun cotton and molten camphor and dissolve the mass in alcohol or ether.

The celluloid is recovered by evaporating the solution, which leaves the celluloid as a solid mass in the evaporating tank. The alcohol or ether vapor passes into a condenser where it is condensed into its liquid form for future use. This process is generally used where the celluloid is used in moulded forms or in thick pieces. When the lumps of crude celluloid have been obtained they are worked between cold rollers for an

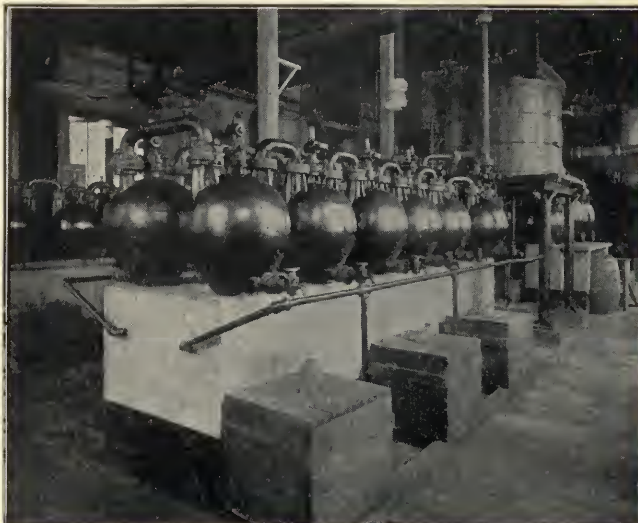


Fig. 21. Interior view of the Eastman nitric acid plant, showing the cast iron condensing receivers where the acid is formed.

hour, so as to make the mass perfectly homogeneous. They are then further treated under hot rollers for the same period of time. During the hot process, the celluloid becomes attached to the rollers in the form of a comparatively thick layer which is afterwards stripped off and pressed into cakes about three-eighths inch thick.

A pile of the cakes are now placed in a hydraulic press where they remain for twenty-four hours under heavy pressure. At the end of this time the cakes are removed, cut into plates and are placed in a dry chamber for a period of from ten to fourteen days. The celluloid stock is now finished, ready for making the films.

A strip of celluloid of the required thickness for a film (.005 inch thick) is made from the block, about 22 inches wide and 200 feet in length. After a thorough cleaning the strip is ready to receive the sensitized emulsion coat in the dark room, which, with the exception of cutting and perforating, is the last step in the manufacture.

In the dark room the strip of celluloid passes under a hopper tank filled with the liquid emulsion. At the

Fig. 22. Centrifugal drying machines for removing all traces of moisture from the cotton.

bottom of the hopper is a slot that extends across the 22-inch dimension of the film, and as the strip is driven past the slot it receives an even and uniform coat of emulsion. After the emulsion has been thoroughly dried, the film is split up into ribbons of the finished size (1⅜ inches wide). The process of pouring the emulsion upon the film is very simple and effective in securing an even coating.

Different emulsions are used for the positive and negative films, the emulsion of the negative being much

faster than that of the positive, as is the case with dry plates and lantern slides.

DEVELOPMENT OF THE NEGATIVE.

After the picture has been taken, the camera man delivers the film to the negative developing department, where it is developed and fixed in a manner very similar to that adopted in developing still pictures. Before proceeding with the development of the entire film, when the exposure and light conditions are unknown, a short piece is cut off and developed independently, so that the proper treatment may be determined without endangering the entire reel.

In some plants the exposed film is wrapped spirally around a light rectangular frame or rack, for convenience in handling, and is then dipped into a tank containing the developing solution. This arrangement enables the operator to agitate the film in the solution and examine it without danger of injury to the delicate sensitized surface. After the negative has been developed to the required density it is placed in the fixing bath of sodium hyposulphite where it remains until all of the active emulsion is reduced, and is no longer affected by the light.

Fixing having been completed, the film is thoroughly washed in clean water to remove the last traces of hypo, and is then given a final treatment in a dilute solution of glycerine and water. A small percentage of the glycerine remains with the film even after it has been dried, and owing to the moisture absorbing properties of the glycerine enough moisture is retained to keep the film in a soft and pliable condition. When the glycerine has been lost after a considerable service, by evaporation or other cause, the film becomes brittle and must be given another treatment in the glycerine bath.

The film is dried upon large revolving wooden drums, usually driven by power. The motion of the drums throws off any small drops of water that may adhere to the back of the film and keeps a constant stream of warm air moving over the emulsion side.

For convenience in developing long films they are often wound around large drums similar to the drying drums. After the film is wound on the drum it is sus-

pended over the developing tank in such a way that the lower edge of the drum and the film dips into the solution. The drum is now revolved until the negative is developed to the proper density, and then is transferred to the fixing and washing baths.

In taking "topical" films or news items for the "weeklies" different sections of the films are exposed under different light conditions or on different days, with the result that some portions of the film are under and others over exposed. This makes it impossible to develop the film in a single length, for each exposure

Fig. 23. Scene in a typical developing room showing the developing tanks.

on the film now requires separate treatment. For the information of the developing department, the camera man places a punch mark at the beginning and end of each of the different exposures. When a film of this nature is received, the developer immediately unrolls the film, cuts it apart at the punch marks, and develops each part separately. After drying, the pieces that relate to the same subject are sorted out and cemented together so that they form a continuous strip.

The subtitles and leaders are inserted at the proper points and the film is carefully examined for mechanical defects. The completed negative is projected on the screen before the heads of the various departments who decide what is to be trimmed out of the picture to bring it within the desired length. When these alterations have been made, the film is given a second showing, and after further criticism all weak and unnecessary parts are eliminated.

In making the titles and sub-titles a set of block letters are generally used, the letters that form the words of the title being arranged in the proper order on the top of a table. A series of pictures is then taken of the letters by a motion picture camera pointed down toward the top of the table. In the film the titles appear as a series of small photographs, very similar to the small pictures.

When written messages are used for sub-titles, the original is lettered on a large sheet by the draftsman. In a few of the plants all of the sub-titles are lettered by hand, but as this is a tedious process it is not as desirable as the block system. Titles in which the letters move across the screen and arrange themselves to form a word are made by alternately moving a letter through a short distance and taking a picture until all of the letters are finally arranged in their positions.

PRINTING THE POSITIVE.

When the negative is finished, it is cut up into lengths of 200 feet for use in printing the positives or projection films. As in making any positive photographic print, the emulsion side of the negative is brought into direct contact with the sensitized side of the positive film, and is exposed to the light in such a way that the light passes through the negative and on to the face of the positive. The image outlined on the sensitized positive creates a picture that is the reverse of that on the negative, that is, all of the light portions of the negative are dark on the finished positive, and *vice versa.* The positives are printed on a much slower film than the negative, but one that gives more contrast and better results in projection. Artificial light is always used in printing as it is possible to maintain an absolutely uniform illumination on the film and is much easier to control than sunlight.

Because of the length of the film and for the reason that the pictures on both the negative and positive must

bear a constant relation to the sprocket holes, a special form of printing machine is used instead of the usual photographic printing frame. The machines containing the printing lamps are used in a dark room so that the sensitized stock can be handled freely without danger of being light struck. The operation of printing requires great care and precision to have all of the pictures of the same density. Uneven printing causes flicker on the

Fig. 24. Joining the films after the development.

screen and an annoying increase and decrease in illumination.

In general, the printing machines are divided into two principal classes, the "step by step" machine, and the continuous or "rotary" type, depending on the method by which the film is fed into the machine.

In any case the machine must take the rolls of negative and positive film stock, press the emulsion sides closely together, and feed them at a uniform speed past the printing light. After printing, the two films separate, the negative being wound on one reel and the positive on another. Printing with a "step by step" machine is

similar in many ways to taking the pictures in the camera, as the pictures are printed one at a time, the film being stepped ahead during the time that a shutter cuts off the light.

The printing light is placed above an aperture in the printing machine that is of the same size as the single picture (¾x1 inch). The intermittent mechanism feeds the film past this "gate." A framing device is provided so that the position of the film can be adjusted in regard to the sprocket holes of the feed mechanism. A device also shows adjustment of the rate of feed and regulates the quantity of light, so that negatives of varying densities may be accommodated.

A "continuous" printing machine feeds the film from the magazine to the take-up reel without the intermittent motion of the machine just described, and consequently is capable of printing more film in a given time. It is not as accurate in the spacing or exposure of the pictures as the intermittent machine, however, for when the two films are drawn by a single sprocket, they are likely to slip on one another.

The development of the positive is practically the same as that of the negative, including the glycerine bath. The only additional feature is the clearing bath which clears the high lights and sharpens the detail. After drying, the 200-foot pieces are spliced into 1,000-foot lengths and are projected on the screen for further examination before shipping. Every plant is equipped with a minature theater in which the films are shown to the officials and players before being placed on the market.

When tinted or monochrome films are desired, they are placed in the tinting tanks before drying.

TINTED FILMS.

"Tinted" or stained films are dyed over their entire surface with a single color, and when projected give the impression of being thrown on a colored screen. The high lights or the light portions of the film is the only part affected from the viewpoint of the spectator for the shadows appear black as in the usual black and white picture. A red stain gives a realistic effect to a fire scene, blue gives the impression of moonlight, and yellow adds greatly to a sunlight view, especially when an open har-

vest field is shown. It is customary with many film companies to tint the titles and sub-titles to reduce the glare of the open lettering.

The color effect of a tinted picture is increased in "monochrome" pictures by tinting only the dark parts of the film with a single color dye. This type of picture is obtained by chemically treating the film with the solution that converts the dark silver deposits into a colored salt without affecting the light or transparent portions. This is performed either with a special developing solution or by an independent process after development, the result being a red on white or blue on white image. A marine view made by the monochrome process, showing white caps on green water, is very realistic. Moonlight scenes, with the shadows in blue and white high lights, give beautiful results on the screen. Both the tinted and monochrome films are inexpensive when compared to the true colored pictures, and are much used, but they are far from being as effective as the pictures that show things in their natural colors.

When the pictures contain more than one color the process of making them is much more complicated and expensive, for then the colors must be applied individually by hand or by a complicated system of photography.

INCOMBUSTIBLE FILM.

Because of the fact that the majority of the daily papers have discovered that celluloid is a product of gun cotton, it has long been the subject of scarehead articles in which its inflammability has been greatly exaggerated. Thrilling tales are told of spontaneously exploding celluloid collars and of yard-high flames leaping from combs and mirror backs. It has even been reported that burning celluloid is impossible to extinguish.

Only those who have handled this material know the absurdity of these statements, especially those regarding its tendency toward spontaneous combustion. While it is true that celluloid is inflammable, and even highly inflammable, it is only possible to ignite it by bringing it into contact with an open flame or by subjecting it to a temperature of several hundred degrees in the field of

the electric arc. Even after ignition, it is much more easily controlled than burning gasoline, as it cannot flow or be spread by the application of water. Its chief danger lies in the rapidity with which the flames spread through the mass due to the distillation of the volatile constituents in its composition. This vapor can only be caused by a generally high temperature surrounding the film; without the vapor, it ignites little easier than paper.

A great number of experiments have been conducted for the purpose of discovering a non-inflammable substitute for the gun cotton base, or for the camphor which is also inflammable. Several attempts have been made to use some substance that will take the place of camphor and at the same time will reduce the inflammability of the gun cotton. Substances have been discovered that have been successful in reducing the inflammability of the film, but which have introduced serious difficulties in the way of brittleness or in the reduction of transparency.

Since the inflammability of the gun cotton depends upon the presence of several unstable high nitro-compounds, attempts have been made to break up or denitrate the substance. Treating the celluloid with amyl or methyl silicate is one process, and titration with an alcoholic solution of calcium chloride in acetone is another. In the latter process the calcium chloride solution, and the acetone, in the proportion of ten parts of the former to one part of the latter, is evaporated and is spread in thin sheets and dried. These strips are difficult to ignite and do not burn after the ignition flame is removed.

A compound of nitro-cellulose and acetyl-cellulose also forms a slow-burning compound. Chloride of tin added to celluloid while in a softened condition produces a film that will burn only when held in the flame. This compound consists of one hundred parts of nitro-cellulose, four hundred parts of camphor, and one hundred parts of alcohol. Kohler's substitute is prepared by immersing nitro-cellulose in acetic ether or acetone; the resulting colodion is then mixed with nitrated cotton that has been dipped in shellac, Canada balsam, or similar solution.

Treating cellulose with strong caustic potash through which carbon disulphide vapor is passed, produces a transparent viscous mass which approximates celluloid. After this treatment the cellulose is removed by a solution of salt water. Cellulose is soluble in acetic acid, and this product, "cellulose acetate," is not inflammable.

While it has been shown that there are several substitutes for celluloid that are non-inflammable, it may be said that all of them are practically failures as far as moving picture film is concerned, and that considerable work remains to be done before perfection is attained.

WATERPROOF FILM.

Every time that the film is run through the projector it is scratched and smudged to a certain extent by the sprockets, and even by the friction of one turn of the film on the other during the process of unwinding from the reels. The particles of dust and grit that float in the air collect between the turns of the film and are ground into the delicate emulsion by the friction. In addition to the scratches and dirt, the film is usually well supplied with the finger marks of the operator.

The scratches and dirt produce what is known as a "rainy film," or a film in which the motion of the scratches on the screen appears as a heavy downpour of rain. A film in this condition is exceedingly annoying to an audience for the "rain" not only obscures the picture but dazzles and tires the eyes as well.

The emulsion side of the film gathers the dirt and scratches because of its delicate and mat-like surface, and as this side is easily softened and destroyed by water it is not practicable for the operator to wash it unless it has been previously protected with some form of waterproof covering. With a waterproof coat it is possible to have the film as clean at the end of the season as at the beginning.

A perfect waterproof coating must be transparent, flexible, and yet perfectly hard under comparatively high temperatures, and should be of such a nature that it will take the cement used for making splices. These conditions have been met by a substances greatly resembling celluloid that makes the emulsion side as hard and shiny as the back of the film. This coating makes the film

slide more easily through the gate of the projector, and also prevents the operating troubles due to the fine dust that is the result of the abrasion of the emulsion.

This coating is applied by passing the film through a bath of the compound by a special machine designed for this purpose. As the process is complicated, and the machines large and unwieldy, the coating is done at the plant of the waterproofing company. The washing is done by a special machine, for the sake of speed, at the film exchanges.

CHAPTER III.

TAKING THE PICTURE.

For a few years after the first appearance of the Edison Kinetoscope, the films were short and displayed only the most common of everyday events. For two or three years a five-minute picture showing a fire engine passing down the street, or a locomotive rushing past a way station were exhibited continuously. The moving picture of this period attracted crowds, not because of the interest of the subject, but simply for the reason that it moved. After a short time the novelty of the moving picture, as a moving picture, wore off and the producer was compelled to offer something more than a machine demonstration. It steadily degenerated until it finally became a "chaser" or tail piece in vaudeville shows, whose sole purpose was to warn the audience politely that the show had ended.

The producers soon realized that the motion picture had reached the critical stage in its career, and began to cast about for features that would reinstate the show in the public regard. The first attempt that led to the modern story picture was the production of a "comic" in which a small boy and a garden hose were the principal characters. The popularity of this "slap stick" film led to a second edifying production in which a black mammy was shown in the act of applying a smother of soap suds to several of her pickaninnies. However crude these pictures may have been, they at least pointed the way to public approval. The public clamored for a story, and finally got it.

The demand for plays led to the complete transformation of the motion picture business. Studios were built with complete theatrical equipment, and actors were employed from the legitimate theaters. Because of the length of the new production means were found by which the old film lengths of forty feet were increased to two

hundred feet, which could be spliced end to end. Writers had discovered a new market for their literary product, and as a result the moving picture attained a new dignity.

The public soon discovered that the photoplay was far more realistic than the plays produced upon the legitimate stage, and that the range of subjects that could be covered by the film were almost limitless. Instead of using scenery, it was possible to produce the act among the actual surroundings demanded by the

Fig. 25. Typical wardrobe room, showing space devoted to the storage, making and alteration of the players' costumes.

play. When the producer required a ship, he did not build one of painted canvas and a few boards, but went and photographed the group of players on board an actual ship that rode an actual ocean. The photoplay filled exactly the ever increasing demand for realism.

About this time the film manufacturers discovered that foreign scenes were attractive to the average show patron, with the result that the "travel" picture came into being. These pictures were not only entertaining but were instructive as well, and are as popular now as

on the day of their inception. The travel picture really marked the final break from the conventional theatric atmosphere and placed the motion picture theater on its feet as an independent and legitimate form of entertainment.

The first notable film of this period was the three-reel production of the "Passion Play," which was produced in New York by Richard Hollaman from the manuscript of Salmi Morse. With the poor facilities at hand at that time for taking a picture of this character, its preparation was a tremendous task and a great financial risk, for no one knew whether it would make an appeal to the public even were the great mechanical difficulties overcome. Beside these difficulties, the producers had to contend with the opposition of the clergy, who had been instrumental in preventing the presentation of the play on the stage.

No expense was spared in its preparation, and when it finally appeared on the screen it immediately became tremendously popular, even among the clergy. Sunday schools attended the performances en mass, day after day the theater was crowded with people whose religious principles had up to that time prevented them from attending a place of amusement. Its success may be judged from the fact that it ran continuously in one theater for six months. Prints were distributed all over Europe and were exhibited with the same success that had met the production at home. This was the first three-reel film that had ever been produced, either at home or abroad.

The tremendous impetus given to the industry by this play, and by the numerous travel pictures that were being shown, started the moving picture boom, and from this time it was easy sailing, at least where the public was concerned. To meet the increasing demand for novelties, the manufacturers then introduced pictures of topical events, pictures showing different manufacturing processes, scientific films, and several other types of educational value. The motion picture projector was becoming an instructor as well as an entertainer.

THE CLASSIFICATION OF FILMS.

At the present stage of development, the films are

divided according to their subject matter into seven principal classes: "Dramas," "Comedies," "Topicals," "Trick Pictures," "Educationals" and "Industrials." According to our idea, the subjects are arranged in the order of their popularity, although not according to their merit. The term "educational" covers a multitude of subjects, such as "scenic" or travel pictures, and films that treat of historical or scientific subjects.

Fig. 26. Camera man equipped and ready for taking a military scene. Note the weight of the camera and film that must be carried in out door work of this nature.

The subjects for topical, industrial, and educational films are gathered in the same way that news items are gathered for newspapers or magazines. When an event of unusual interest is about to take place, the producer sends a camera man to that locality to take the pictures. The larger manufacturers have camera men constantly on the road, seeking for novelties or news items, and as a result there are few events of general interest that escape the lens of the moving picture camera. The taking of these pictures is usually an exciting and hazardous

occupation, and contrary to the general opinion they are seldom "faked." Pictures have been taken from balloons, aeroplanes, from the tops of unfinished skyscrapers, and on the battlefield.

Dramatic films which tell a story through a series of related incidents are equivalent to the drama of the "legitimate" theater in all of the essential details, except of course that the action is expressed entirely in pantomime. The incidents of the film drama, like that of the legitimate drama, are based on a story or manuscript known as a "scenario." Provided with the scenario, the

Fig. 27. Taking the pictures of a military scene in the field. The production of this play necessitated the employment of several hundred "supes," and took several weeks of rehearsal before the action was ready to film.

players go through the play before the camera as in an ordinary theatrical performance, the camera playing the role of "audience." The interior scenes of these plays are enacted in the studio of the manufacturer. The exterior views are of course taken at the place designated by the scenario, which may be any place south of the Arctic circle or north of the Antarctic. Trick pictures are invariably studio productions.

Film comedies correspond to the comedies of the stage, and are photographed in the same way as the dramatic films, either in the studio or at some place that is in accordance with the scenario. As comedies are

Fig. 28. Taking a studio scene, showing the arrangement of the scenery and the position of the camera. The director in the middle foreground is explaining the action of the scene to the players.

based upon some story, a scenario is provided for their production, similar in nature to that furnished in the dramatic films.

Trick pictures are really sleight of hand performances that are made possible by the special manipulation of the camera. By running the camera backwards, or by substituting dummy objects for the real ones, the photographer is able to perform many wonderful feats that are deceiving to the audience. The effects obtained in trick pictures usually border on the comedy form, although some of the illusions, notably the vision projection, are sometimes utilized in the dramas. Trick pictures require a great ingenuity both in the conception of the trick and in the mechanical features of the camera manipulation, and are deservedly popular.

In the early days of motion picture photography, the stage was located out of doors in a small shed which was left open in the front and closed in on the remaining three sides. The enclosed sides served both as a protection against the weather and as a support for the scenery. In the majority of cases there was no roof over the stage. The floor of the little building was elevated a few feet above the ground and served as a stage on which the plays were enacted. The camera was installed in a small house directly opposite to the open side of the stage so that the lens could take in the full width of the building.

Both the studio and the camera house were mounted on a common platform that was free to turn in any direction like a turntable, so that the open side of the stage could be faced toward the sun. By this means it was possible to secure any desired illumination on the scene. As it was possible to take pictures in this type of studio only under favorable weather conditions, and for the reason that the wind caused unnatural effects on the draperies and clothing of the players, it was soon abandoned for the glass enclosed studio of the present day.

The present studios are enormous glass-enclosed buildings, greatly resembling giant hot houses in their external elevation, and are generally of the steel frame type of construction. Both the roof and sides consist of continuous glass paneling, so that it is practically as

light in the studio as out of doors. Steel trusses carried from columns on the side do away with all intermediate posts, giving a clear floor space. With a studio of this construction it is possible to carry on the work under almost any weather conditions, with natural light.

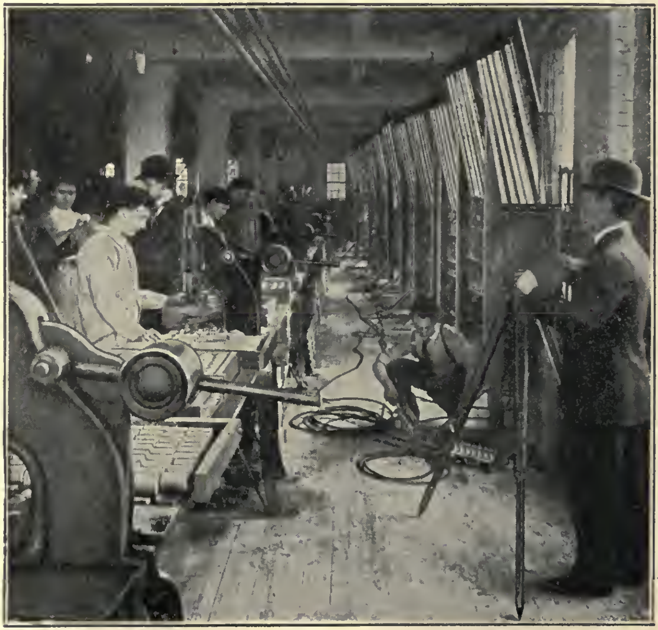


Fig. 29. Showing how an "industrial" film is taken in a factory. The rows of vertical tubes on the right of the picture are Cooper-Hewitt mercury vapor lamps used for illumination of the dark interior. A film of this nature has a great educational value in the motion picture theater, and is of great value to the manufacturer who wishes to have his customers become interested in the inner workings of his plant.

At night or in very dark weather the studios resort to artificial lighting, this being accomplished by the use of electric arcs or mercury vapor lamps, the latter being the most economical. The green light given by the mercury vapor lamps is very effective in registering the image on the photographic film, and requires a minimum of current for a given illumination. These tubes are usually arranged in groups of six tubes per group, and are hung

either from the roof trusses or the side of the building. Usually eight groups of lamps are used for the illumination of a single stage setting, and these lamps are sometimes supplemented by arc lamps hung from the trusses. In some studios it is possible to concentrate over 100,000 candle power on a stage.

The scene itself occupies but a small amount of space on the studio floor, the width of the set usually being about 14 feet, and with the enormous floor area at the disposal of the director, it is possible to conduct several scenes at the same time. These small spaces are marked out on the floor, and the scenes or wall sets are erected inside of the space, forming in most cases a three-sided box that is open at the top for the admission of light. When an actor is to disappear from the scene he simply walks through the door in the set and is immediately out of the range of the camera. The ease with which a player may unconsciously disappear from a scene in which he is supposed to be taking part requires constant vigilance on the part of the camera man and director.

The scenery used in the studio resembles that used on the stage except that no colors need be used on the canvas. Neutral tints, or plain black and white outlines are more desirable for the reason that colors such as red or blue give misleading color values on the film. The walls used in interior views are only large enough to cover the field of the camera and are built in section for ease of handling. As the plays vary in character and period, it is seldom that the same set can be used more than once. This constant change in the scenery calls for a large force of scene painters and stage carpenters.

The "property" rooms of the large film manufacturers, in which the properties or appliances used in the play are kept, contain nearly every conceivable object known to man. Guns, stuffed animals, bottles, druggists' signs, policemen's clubs, brass beds, wooden beds, hoop skirts, cannon, harness, clocks, furniture of all classes and age, and a tremendous catalogue of other things that are far too numerous to list in the limits of this book are constantly kept in stock. As can be imagined, a very considerable fortune is tied up in the property room alone.

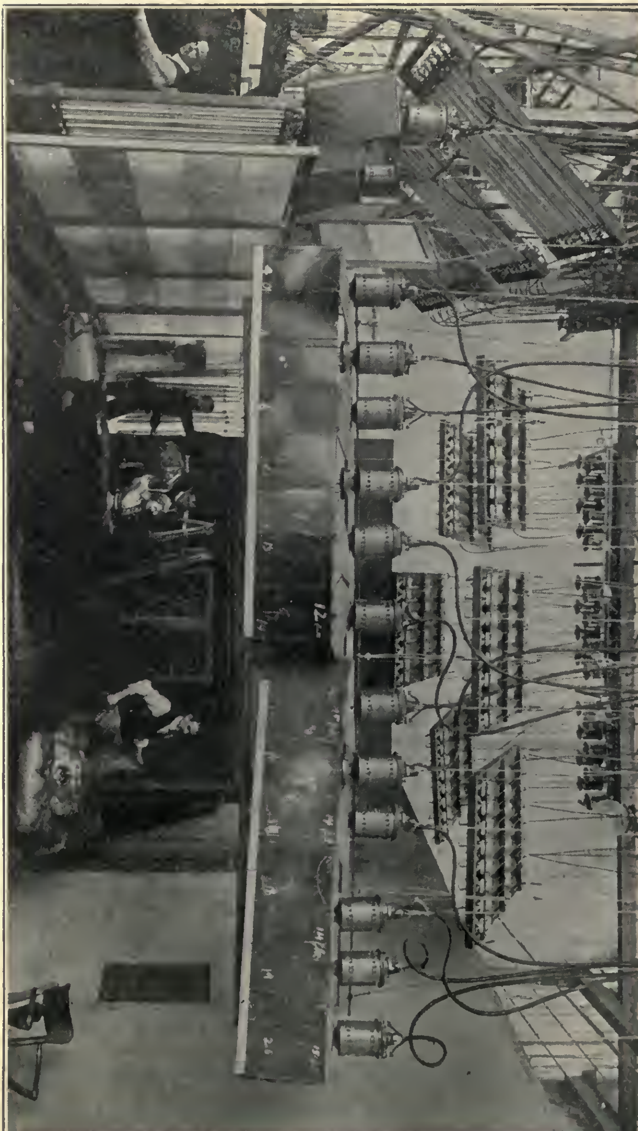


Fig. 30. An example of a studio illuminating system showing the great amount of electrical energy necessary for the lighting of a scene. There are 80 arc lamps and 15 banks of mercury lamps having 8 tubes per bank.

As the film shows all periods of history and every condition of life, a very extensive wardrobe is required. It is claimed that one studio that specializes in historical and military subjects has over eight thousand costumes ready for instant use. At a moment's notice the costumer can supply a small army with uniforms, equip a tribe of Indians with their tribal costume or produce the most modern of ball costumes for a society play. High hats or the furs of an arctic explorer are equally in evidence in this remarkable department.

THE PRODUCER.

The producer is the principal factor in the management of the studio and in the production of the plays.

Fig. 31. Studying the strength of a fly. An example of an educational film subject.

In commercial life he would be called a superintendent, and in the theater a stage manager. From the time that the scenario is first put to his attention until the negative has been delivered to the developing department, he is constantly on the job in directing the work of the players and scenic mechanics. On the receipt of the scenario, the producer, or director as he is sometimes called, makes such additions as he thinks necessary, and notes the details of the scenes and properties required for the play. After the lists of scenes and properties have been made, orders are given to the scenic and property departments for the making of the various sets. Costumes are selected and in the case of an outdoor scene, the producer determines on the proper locality for the action. While this work is in progress, he selects the players and calls for a rehearsal.

Fig. 32. Taking a "yard" scene in the rear of a film manufacturers' studio. The nature of the buildings and scenery may be seen at the right. The "tank" used in producing aquatic scenes is in the middle foreground at the left.

If the scene to be rehearsed is a studio act, the stage is set completely, and the actors appear in full costume. The camera is set in position so that the operator may become familiar with the act, and the rehearsal proceeds. After a number of additions or subtractions made by the producer to improve the scene or to bring it into the time limits of the film, it finally receives his approval, and the camera is started. If any mistake is made during the filming of the play, the film is destroyed and the act is repeated until it meets the approval of the producer. In the case of films that are difficult to obtain, or expensive, two cameras or a double film camera are used, so that there will be no chance of losing the act through a light struck film or an accident in the developing process. When two films are taken by two independent cameras a choice may be had between the two films, one of which will undoubtedly be better than the other.

In the case of out of door scenes, the play is generally rehearsed in the studio before going into the field. This practice is always followed in the case of street scenes, where the throngs of spectators would interfere with a prolonged rehearsal. The time in the field is cut down to the lowest possible limit, for the weather is likely to change at any moment and the expense of maintaining the players in the field is much greater than in the studio.

THE PLAYERS.

The players are frequently recruited from the theaters, although there are many motion picture actors that have been developed in the studios simply through their association with that line of work. It is customary to hire some actors for a day at a time because of the fluctuations in the studio demands. One day, the producer may require as high as fifty players and on the next less than half that number, depending on the character of the play then being produced. For the leading parts, the producing company maintains a small body of players known as the "stock company," which are kept continuously in the service of the company at a fixed salary.

The selection of the actors and actresses is by no means an easy task for they must not only be masters

in the art of pantomime, but must look their part as well.

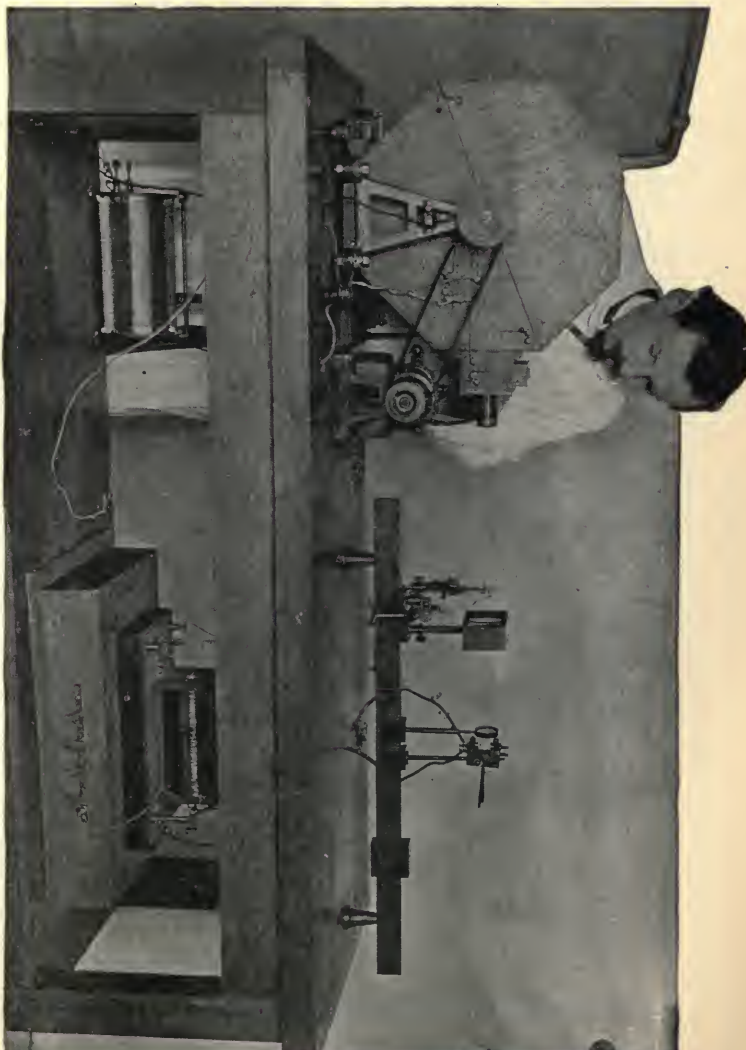


Fig. 33. Laboratory apparatus used in taking microscopic motion pictures of small insects and germs.

The camera is a merciless critic, and exaggerates every awkward gesture or facial peculiarity of the player, and

defects that would not be noticed on the stage are glaringly apparent on the screen. It is almost impossible to "doctor" up a character with grease paint, for the magnification of the projector would make such an attempt ridiculous. It is almost impossible for an old man to take the part of a young man, or vice versa, and deceive the audience. An old woman may assume the part of a girl in the legitimate drama and succeed, but never before the camera.

Stage make-up is out of the question in the motion picture studio for the pinks and yellows so commonly used in getting flesh tints are distorted in color value in the film. Any tint containing red is recorded on the film at least in three shades darker than the original color, for this color has practically no actinic value. As the areas covered by the red undergo no changes due to the reduction of the silver in the emulsion, the positive is printed black under these transparent spots in the negative.

In nearly all cases the face is first thoroughly whitened and then tinted with yellow so that any subsequent color that may be applied will stand out in bold relief, and also for the reason that the face will appear white instead of grey, as would be the case with the natural color of the complexion. The lips and the area surrounding the eyes are tinted with a color having a bluish cast such as heliotrope or mauve. When seen in the sunlight, the make up of the motion picture actor presents a most ghastly appearance.

In spite of their extended experience on the stage, there are but few actors who have the faculty of expressing themselves in pantomime, even in the minor roles. When an actor is discovered that possesses this rare gift he is frequently put in the "stock company" maintained by the producing company at a fixed monthly salary. Should he have a specialty in which he appears to the best advantage, he is made the "star" in some series of films having the same title, such as the "Broncho Billy Series" issued by the Essanay Company. In a film of this nature, the star is given a characteristic name which appears on all of the films in the series, each issue representing some episode in the life of the hero.

TAKING STUDIO PICTURES.

At the time arranged for the rehearsal, the company assembles on its allotted stage and receives specific instructions from the producer in regard to the "business" on the stage, how to make their entrance and exit, and also instructions regarding the dialogue. The producer usually goes through the principal parts of the play to convey a general idea of his requirements before the rehearsal. After this demonstration the players go through

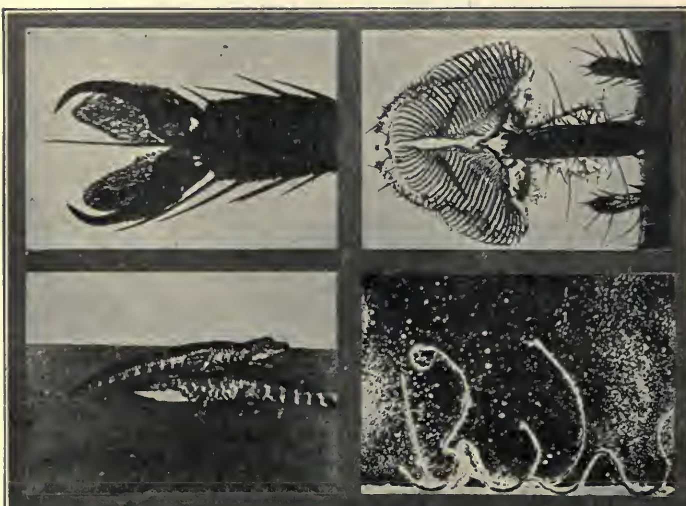


Fig. 34. An example of an "educational" series. The upper pictures are microscopic views of the house fly showing its tongue and feet. The lower pictures were taken through the glass sides of an aquarium of different forms of amphibious life.

the play for the first time, the cues being given by the producer, and if the action seems to lag, he immediately jumps into the scene, assumes some part, and stirs things up until the actors have grasped his idea of the speed and spirit.

Time after time, the scene is rehearsed, little modifications and additions being made each time, until the show goes with the proper swing. Often the company is made to go through the action a dozen or more times before everything is satisfactory. When a scene re-

quires animal actors, the rehearsals are almost numberless, for it is exceedingly difficult to keep within the field of the camera.

During the last rehearsals, when the action is nearly perfect and the rough edges are worn off of the work, the camera man and the producer start to take the time of the scenes. Watch in hand, they follow the work through from end to end, noting parts of the business that could be trimmed out, in the event of overtimed action. When the final rehearsal is completed, the

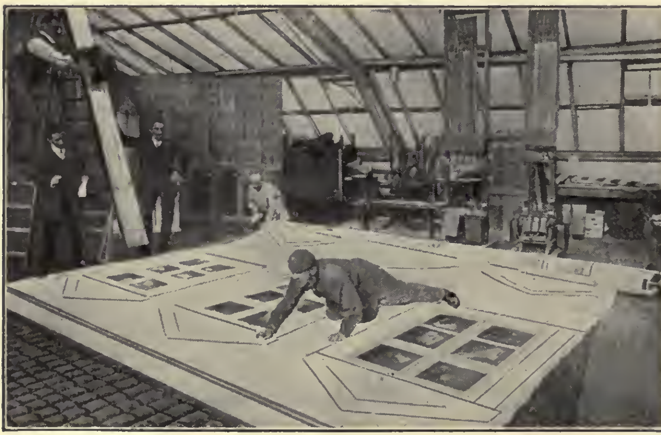


Fig. 35. One method of making a well known form of "trick" picture. By laying the scene flat on the studio floor, and taking the view from an elevated position, the man will appear to the audience as crawling up the side of the building.

camera man and the producer compare notes regarding the time taken, and the time allowed on the manuscript. Should the time be too long, the producer condenses the action by ordering the players to make quicker entries, or by cutting a dialogue, a few seconds may be gained. When enough has been clipped, according to the judgment of the producer, the play is again rehearsed with the alterations, and is again timed. If the scene is still too long, further alterations and rehearsals are made until it is made within the limited time.

All is now ready for the filming of the scene. The players that are to be "discovered" at the opening of

the picture take their places on the stage, and the camera man makes the necessary adjustments to his machine.

Fig. 36. "The Magic Coffee Pot" with the mystery removed. This is an example of that class of trick picture in which inanimate objects appear to go through various evolutions of their own accord. The coffee pot in this case is suspended by fine wires that are invisible in the finished picture.

As a guide to the limits of the camera, conspicuous "markers" are placed at the extreme edges of the scene

to be covered by the camera. These enable the camera man to determine whether the players are "off" or "in" the scene.

At the word "Ready," given by the producer, the camera man starts cranking the machine and the actors stand alert for their cues to enter. An instant after follows the order, "Start your action." From this instant, the studio, or at least that part of it in the vicinity of the stage is a bedlam of noises. The players jabber their almost meaningless lines, the producer shouts his directions to the players in which he is accompanied by the camera man. "You're out, Kelly," "Faster-faster-faster," "Cheer up Miss Davis," "Up in front, you with the hoop skirts," "Not so far," "Roll your eyes," etc., etc. From the direction of the stage come the broken fragments of the dialogue, "I never, never will leave you." "Ouch," "My boy," "I love you," and so forth. The players are worked up to an exciting pitch, and the play is at its height, when the eye of the producer catches an error in the action or an actor off stage. "Stop," he shouts. The camera immediately stops its purring, the offender is treated to some forcible remarks from the director, the spoiled film is thrown out, and the play is started all over again. This may happen several times before a perfect film is obtained.

Only persistence and patience on the part of the producer will obtain good results in a film play. The management of the actors before the camera is a far more exacting task than on the stage, for in the studio every second counts. Every second means a foot of film, and film costs money. Situations must be handled that occur in no other branch of the amusement field and require instant judgment on the part of the producer. The greater proportion of the actors employed are not thoroughly conversant with the requirements of the studio, and are not quick to adapt themselves to the new conditions under which they are working.

At the close of a successful scene, the producer shouts "stop," as a signal to the operator to cease his cranking.

"How many feet," asks the producer of the operator.

"One hundred and sixteen" is the answer.

If this is within the prescribed limits, the next scene is started, that is if it is a studio scene. If there are several intervening scenes that are exterior views, they are omitted for the time being and the next studio scene is undertaken. To economize in time, the next scene has, in all probability, been set up in the vicinity of the first, during the time in which the first was photographed. The players now move from the first to the second stage where the camera is again set up.

YARD PICTURES.

Nearly every firm has a fenced-in space in the vicinity of the studio where most of the outdoor scenes are taken that require special settings. In the "yard" will be found reproductions of foreign and historic buildings, mimic lakes, and miniature mountains, in fact, all scenic effects that are too large for the indoor studio. The architecture of the buildings in the yard is of the most varied description, ranging from Grecian temples to Esquimaux huts, and from old German castles to Chinese pagodas. By simply revolving the camera on its axis, the operator can cover a thousand years of architectural development.

Generally the construction of the yard scenes is similar to that of those in the studio, except that they are of a sturdier and more permanent type. The majority of the buildings are provided with only two or three sides, as with the interior scenes of the studio, and are only high enough to cover the field of the camera, when taken from a comparatively short distance. Roof scenes extend only a few feet from the ground, so that the player in leaping from the roof of a building has only a short distance to fall. By directing the camera upwardly, so that the ground line is not shown on the film, it is possible to obtain some very realistic effects in fire scenes.

The tank, which is included in the yard equipment of every large plant, is one of the most useful of the properties. By suitably disposing the scenery around its edges, it can be made to represent any imaginable body of water from a brook to an ocean. The tank at the plant of the Selig Polyscope Company's plant contains about sixty thousand gallons with a depth of about three feet. It is supplied with row boats, small bridges, and at one

end is provided with an extension that forms the mill race for a small mill that is built near the edge.

Near the center of the yard is a cylinder about thirty feet in diameter which is mounted on a turn table device so that it can be rotated rapidly in a horizontal plane. On the outer surface of the cylinder is stretched a canvas scene, usually of mountainous or broken country. When the camera is placed in front of the rotating cylinder, the speed of the screen gives an effect of traveling through the country displayed on the canvas. This effect is heightened by placing a car interior scene between the camera and the cylinder so that the latter may be seen through the car windows.

TAKING TOPICAL FILMS.

The topical films, in which the events of the day are shown, are fast becoming one of the most important mediums of distributing news items. There are but few theaters in the United States that do not display one of the numerous "weekly reviews." While the papers may print the news several days in advance of the release of the film, the items are never stale when projected on the screen, for the pictures impress the audience with entirely new ideas concerning the subject. To hear about an event is one thing, to see it is another.

The motion picture theater patron is kept in touch with the progress of the world through the medium of the topical film for there are motion picture operators in all countries whose sole duty is to keep informed as to the events taking place in their particular section of the map. Everything from a prize fight to the funeral services of a king are subjects for the topical, it being in fact an animated newspaper of which the camera man is the reporter.

The success of the film depends entirely upon the judgment and aggressiveness of the operator in overcoming the opposition usually raised by the police or persons in control of the proceedings. The camera man must be a diplomat, a photographer, and a producer rolled into one. He must be absolutely fearless, for his duties will take him from a shipwreck to a battle field or mine disaster, with little side trips in aeroplanes and balloons.

Many a camera man has gone out on a job and never returned.

Speed is a most essential item in the production of a topical, for, as in newspaper work, one film company tries to beat the other to the screen, or to obtain a "scoop." Every minute that elapses between the taking of the picture and its delivery to the theater means money to the film manufacturer, for his efforts and expenditures will be in vain if his rival projects the picture before he gets it on the market. This adds another burden on the operator, for he must not only get a favorable position for the taking of the picture, but must also make arrangements for its prompt delivery. In the isolated parts of the world, where the topical operator performs most of his work, prompt delivery requires careful management and good judgment on the part of the camera man.

Another feature that adds to the difficulty of taking topicals is the fact that there can be no rehearsal of the action, and therefore the operator has to estimate the best camera positions and the length of the film. To be caught short of film in taking an important event is a calamity, for it is not easily procured at short notice, and if the home plant is at a considerable distance, it means failure.

An operator was sent to New York by a Chicago firm to obtain pictures at the terminus of the cross country flight made by the aviator Atwood. He was supplied with only two reels of film, for it was expected that there would only be a few hundred feet of film needed. On the day of his arrival, a fire broke out in a tailor shop that offered an opportunity for a thrilling picture. This placed the operator in an unfortunate position, for he had only enough film for one event, either that of the aeroplane or that of the fire. He chose the latter, and was rewarded by a most spectacular picture, in fact it was the best fire picture that any firm had ever had the opportunity to produce. He packed up immediately and started home, believing that he had chosen the best course, but was disagreeably surprised to find, after the development, that the board of censorship refused to sanction the film. His trip, of course, was a total loss, simply because of the lack of film.

PICTURES IN THE FIELD.

The out-door scenes that form a part of nearly every film story are the most realistic and interesting parts of the film. When properly selected they not only add to the atmosphere of the play, but have a certain educational value as well. Locating the scenes among the Atlantic fisheries or in the mining regions of the West, for example, carries the stay-at-home show patron into interesting and unfrequented places, and gives the film the value of an industrial or travelogue. Scenes laid in the streets of large cities are of great interest to the audience of rural theaters, and scenes of ranch life are of the same value to the city man.

While it is possible to make an acceptable street scene in the studio or yard, with painted scenery in which no foliage appears, no studio scene can be made of natural objects that will in the least deceive the audience. All hand-created scenes including trees or shrubbery lack entirely the detail and beauty of the original and in the majority of cases the studio canvases contain some incongruity that entirely dispels the illusion for which they were made.

The demand for natural settings has resulted in the establishment of branch studios all over the country, each branch maintaining a corps of competent players. By this means a single manufacturer can produce plays in any desired natural setting with a minimum of trouble or delay. "Westerns" are invariably taken in their proper locale, the "supes" usually being drawn from the ranches and towns surrounding the studio.

The great majority of the Western studios are located in California because of the great variations in scenic effects that can be obtained within a short radius. The Pacific Ocean affords opportunities for marine views, the Sierras and the Mojave Desert which are within a few hours of the principal studios, have formed the background for many historical and scenic films. The climatic conditions are ideal for motion picture photography, it being possible to obtain out-door views in semi-tropical settings during nearly every season of the year.

When the producer has selected a suitable site for the out-door scenes, and has rehearsed the act in the

studio, the players are sent to the locality, costumed and made up. If it is to be a street scene, great secrecy is observed until the camera has been set up to prevent interference from the throngs of spectators that are sure to gather in the vicinity. The players are now put through their parts as rapidly as possible under the direction of the producer, the method of procedure being exactly the same as with the studio pictures. Street pictures require all of the resource of the producer in keeping the curiosity stricken spectators from getting into the field of the camera, or from confusing the players in their work. Often times a dummy camera with a fake show in front of it is used to draw the attention from the main event. The relief company making more noise than the one actually being filmed is usually successful in attracting the majority of the audience.

Many comical incidents, themselves being worthy of being filmed, are constantly encountered by the street scene producer. Police interference is one of the most common interruptions, especially with scenes of a highly dramatic nature in which the characters enter into a mimic combat. Attracted by the crowd and the uproar, and not noticing the camera, the unsuspecting policeman has often broken up the work and arrested the players on serious charges, in spite of the explanations of the producer. One company was held for several hours on a charge of attempted arson before the police judge could be convinced that he had broken up an exceedingly realistic photo-play.

Trick street scenes, commonly known as "stop" pictures, in which some extraordinary accident occurs, require a comparatively long time for their production and, therefore, must be taken on some quiet side street, or at a time when the street is practically deserted. Pictures that show a person being knocked down by an automobile or being run over by a street car, are really trick pictures, being obtained by several stoppages of the camera, during which time a dummy is substituted for the real player. By careful manipulation of the camera it is possible to obtain very realistic illusions by taking the pictures and shifting the object alternately.

One picture of this class was very clever both in the conception of scheme and in its execution. At the opening of the film a man was shown lying on the street car tracks in the foreground. A car rushed past, cut off both legs at the knee, and tossed them into the gutter. A number of people, horrified at the accident, rushed to his aid, but to their surprise the victim slowly raised himself from the track, smiled calmly upon his would-be rescuers, and beckoned to the severed members lying in the gutter. Finally one of the legs was seen to start in his direction, hesitate, and then attach itself to the stump in its former position. This having been accomplished, the other leg performed the same miracle, and to the amazement of the spectators, the supposed cripple picked up his hat and walked off the scene.

This illusion was obtained by using alternately a cripple, a straw-filled dummy, and a player with the usual number of legs. The dummy was placed on the track and a few feet of film were run off. A signal was then given to the street car and more pictures were taken while it passed over the dummy, the legs being jerked into the gutter by means of cords at the time that the car was in the picture. As soon as the car passed out of the picture the camera was stopped, the cripple was laid in the position formerly occupied by his straw counterpart, and the camera was restarted. By means of strings that extended to the opposite side of the street, one of the party pulled the legs up to the cripple. The camera was again stopped, the cripple was removed from the scene, and his able-bodied companion was put in his place. After a few feet of film had been run, the player rose and walked out of the picture.

Many of the train and automobile wrecks are not faked but are actual collisions between real machines, the occupants, of course, being removed at the moment of the catastrophe. Many thousands of dollars have been spent by the film companies in wrecking automobiles in front of the camera, and thrilling pictures have been obtained in this way. In one picture showing the results of a joy ride, a perfectly good fifteen hundred dollar car was run over the edge of a cliff and smashed on the rocks below. In this film a dummy was placed in the car before it was

started on its way to destruction. In another film a locomotive and two freight cars were derailed and run over an embankment at a cost of about twenty-five hundred dollars.

Professional acrobats, high divers and aviators contribute their mite to the motion picture show in pursuit pictures, and in thrilling escapes and rescues. A recent film in which the hero escaped from his enemies by jumping off a ninety-foot embankment and into the river was a record of an actual leap by a well known high diver.

Fig. 37. A terrible automobile tragedy performed on a three foot stage with a toy automobile. Not all of the automobile accident films are taken in this way, however, for in a recent release a full sized machine was run over an embankment.

The tumbling and grotesque feats of the "chase" pictures are always performed by professional acrobats, for no human being, without experience in this line, could survive the banging and whacking strenuosities of this class of film. The collisions are real collisions and the falls are real falls.

As the operation of an aeroplane requires considerable skill and practice, the real aviator is always substituted for the character in the play before the machine leaves the ground, although the passenger is usually one of the players. In some cases the aviator has been coached so that he carries the part through alone, from start to

finish, without the aid of the players, and without substitution. When the pictures are to be obtained from above, the camera man accompanies the aviator.

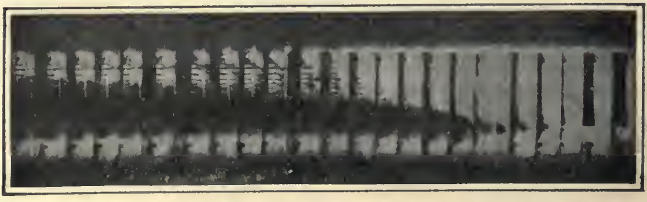
Fig. 38. Taking a trick aviation picture. The two toy aeroplanes suspended by cords are "crossing the channel" in which two miniature ships are floating. A rotating fan at the rear of the scene produces ripples on the water. At the present time the full sized aeroplanes are so common as to make this procedure unnecessary, it being an easier matter to take the real machine in flight.

TRICK PICTURES.

Motion pictures are particularly well adapted for creating illusions. Fairy stories in which the characters

appear and disappear as by magic, lend themselves particularly well to the photographic process, and almost any nightmare, no matter how grotesque or weird, can be reproduced by a clever manipulation of the camera. The French producer, Melies, who was at one time a prestidigitateur, was among the first to take advantage of this property of the camera and to make trick pictures, his first productions being repetitions of the tricks performed by him on the stage.

Cut *A* shows a strip of wood being crushed by a bullet issuing from the revolver at the right of the picture.



Cut *B* shows a bullet entering the end of a lead tube filled with water, the top of the tube being perforated with small holes from which the water may be seen to rise.

Fig. 39—Photographs of projectiles moving at high velocities are taken at the rate of 6,500 per second by means of an electric spark. When run through the projector at the ordinary rate the bullets pass very slowly across the screen so that every movement can be clearly seen. (To see the pictures in their proper position, turn the book so that the outside edge of the page is at the top.)

After extensive experiments with the simpler subjects, he gradually evolved the well known type of picture in which tools and toy animals move about on the screen, as if endowed with life. These were followed by the vision scenes and spectral subjects that were produced by means of double exposures and double printing. As the art of motography developed the trick pictures became harder and harder to produce, for the stock of subjects was becoming scarce, and the audiences more sophisticated and critical. This, of course, resulted in a greatly increased cost of production, so that trick pictures are

now seldom made unless some entirely and radically new idea has been received by the producer.

In a general way, there are three methods of obtaining illusion by means of the camera. First, by periodically starting and stopping the camera in such a way that certain acts are performed by the subject during the time that the camera is stopped. Second, by reversing the routine on certain portions of the film in regard to the remaining parts, and third, by making two superimposed impressions on a single film. While there are many variations in taking the pictures, nearly all of them depend primarily upon one or the other of the three principals, or upon the use of faked scenery or dummy figures.

"A stop" picture, in which dummy figures are substituted for the real actors while the camera is stopped, or in which inanimate objects are moved alternately with the exposures, are among the most commonly used of the effects. By this means it is possible to make toy animals perform circus feats without apparent aid, tools can be made to work without human supervision, or the actors can be made to go through the most impossible or dangerous feats without the least exertion or risk to themselves. An example of this class of picture is shown in Fig. 36, entitled "The Magic Coffee Pot," in which the man in the foreground moves the bottom of the coffee pot upwardly by a series of jerks, a picture being taken directly after each movement of the cords. If he raises the pot one-sixteenth of an inch for each picture there will be sixteen pictures taken for every inch of movement, which, at the ordinary rate of projection, will take one second to reproduce on the screen. Decreasing the movement per picture naturally increases the time of projection.

Practically the same method is used in pictures where a character in the picture is to go through some experience that would be impossible in real life. In this case, the action is carried along in the usual manner until the point is reached at which the accident is to occur, or the point where a dummy must be substituted for the real actor. The producer now shouts to the actors to "Hold it," whereupon all of the actors instantly stop their action and remain motionless, in the position in which they were caught, and the camera is stopped. The hero of the story

is now removed from the scene and the dummy is substituted, arranged as nearly as possible in the original position of the player. Everyone now receives the signal to go ahead as usual with the play until the point is reached where the player is to reappear as in life, when the same plan of stopping the action is repeated.

Fig. 40—Taking a scenic from the pilot of a locomotive, a rather disagreeable and dangerous task for the operator.

Nearly everyone has seen the "reversal" pictures, in which objects in the picture suddenly reverse their usual direction of progress, or in which the characters in the scene perform such feats as jumping over high walls or

leaping from the water to a dock. In the former case, the motion is carried out in the usual way, but the relation between the motion and the order in which the pictures are taken is reversed by means of either a "reversing crank" on the camera, which changes the direction of the film, or by turning the camera upside down. In some cases a special printing machine feeds the negative film in a direction opposite to that of the positive during the process of printing, so that the relation of one portion of the film is reversed in regard to that portion that immediately precedes it.

Another interesting film of this class is that showing the complete erection of an office building during a few moments run of the film. The pictures in this case were actually taken of the building while it was being torn down, a few pictures being taken at short intervals from the time that the wreckers started until they completed the job. When this film is run through the projector in a reverse direction it gives one the impression that he is witnessing a record breaking building job, for, due to the reversal, the building line raises instead of falls.

Ghost pictures, or pictures in which a vision or dream is shown, are obtained either by exposing the negative twice before the development or by double-printing with two negatives on a single positive film. In either case two separate stage settings are used, one containing the scenery and the principal characters, and the other showing the ghost or vision. When the latter scene is superimposed on the other it appears as a thin, vaporous impression that strongly suggests the ordinary idea of a ghost or the intangibility of a dream. The fact that the furniture or furnishings of the room show through the outlines of the ghost, as if it were transparent, greatly heightens the illusion. Only light colored or white figures can be used with good results, since dark figures would obscure the surfaces that lay immediately behind them.

In taking the picture the first exposure is made of the scene and the "material" characters in the ordinary way, with practically the same exposure in order to bring out the details. When this is completed the ghost is placed on a stage that is set in dead black, so that there will be no record of anything but the ghost. The film is

Fig. 41. With a toy train and carefully arranged scenery it is possible to obtain a most realistic view of a railway wreck. This is one of the rainy day jobs undertaken at the studio.

now rewound and is again passed through the camera until the point is reached where the ghost is to appear. The diaphragm is now slowly opened, with the camera running, so that the image of the ghost gradually gains in strength until the full illumination is gained, which of course, gives the audience the impression that the ghost has developed out of the empty air. After the ghost has gone through with its "business" the diaphragm is slowly closed, causing the ghost to gradually fade away.

Vision pictures are more complicated than the ghost pictures, the majority of this type including scenery or interior acts as well as the players. This necessarily requires a blank surface for its projection, such as a wall or a panel, as the outlines of any part of the first scene would detract from the clearness of the vision. Scenes in which a number of men are tossed about in an explosion are usually obtained by a double exposure of the negative, the first exposure being taken of the men in the desired attitudes, and the second of a puff of white smoke that is backed by a black background. Superimposing the two pictures gives a print that shows the players enveloped in the smoke clouds.

Substituting small scale models for the actual subject has been followed in still photography for so long that its application to the moving pictures will be dismissed, the figures that accompany this chapter giving a clear idea of the general methods employed. While this system has been used extensively in showing accidents that would ordinarily be impossible with full size apparatus, it does not follow that all sensational films are produced in this way. In many cases locomotive collisions, automobile accidents and aeroplane "stunts" have been carried out with full scale machines, productions that have cost many thousands of dollars.

By employing black backgrounds that destroy all sense of perspective, and by putting the different parts of the scene at different distances from the camera it is possible to produce the midget fairy pictures that have been so popular. The small figures that perform on a table top in the presence of a "full sized" audience are produced by putting the audience in the immediate foreground while the players are thrown back of the stage far enough

to reduce their height to a few inches, the level of the stage being arranged so that the feet of the players coincide with the top surface. Since there are no connecting lines between the players and the figures in the foreground, due to the black drop, there is no apparent perspective, and, as a result, the players appear to be in a direct line with the figures in the foreground.

The same result may be obtained by the use of mirrors instead of a black drop, the players in this case being placed in front of the stage and beside the camera. The mirror is placed in a suitable frame or panel in line with the audience. When light is thrown on the players the image is reflected back into the camera, by the mirror, much reduced in size, since the effective distance of the player is increased by the length of the light beam from the stage to the mirror and thence to the camera. When the lights are extinguished on the stage, the players disappear from the scene, leaving the figures in the foreground at the same intensity. They may be made to fade away by gradually dimming the light, instead of cutting it off suddenly.

CHAPTER IV.

THE SCENARIO.

In order to proceed intelligently with the making of a photoplay, the actors and director are provided with a synopsis or outline of the action which is known as a scenario. The scenario not only contains a condensed outline of the plot but also gives the list of characters, a description of the various scenes, and a list of the "properties" used. Provided with this manuscript, the director selects the actors that he thinks would be suitable for the characters, and in the case of out door plays, determines on a desirable locality for the action. From the same source, the costumer and property men receive the information for the making of the costumes and various "props" entering into the picture.

During this period of preparation, the actors are studying the parts assigned to them so that they will not only become acquainted with their own work, but with the spirit of the play as well, so that the individual parts will be in harmony with one another. When these preliminaries are completed, the director calls for a rehearsal, at which the players are put through their parts until they are able to successfully express themselves in pantomime. In plays having complicated situations, especially in historical plays, or pageants, the rehearsal may extend over several weeks before everything is ready for the camera.

As a one reel play is generally limited to 1,000 feet, it is the duty of the director to regulate the speed of the acting and the length of the scenes so that the action will be accomplished within the length of the film, a period of about twenty minutes. If the play has many scenes, some must be shortened or others lengthened so that the total time amounts to twenty minutes or less. In arranging the "schedule" of the scenes, the director is guided both by his watch and by the register on the camera that records the number of feet exposed.

During the rehearsal, the players are either assigned, or assume a dialogue that corresponds in a rough way to the pantomime. While the speech is not reproduced by the projector, it is a great aid in attaining the correct facial expression, and makes the picture much more natural.

WRITING THE SCENARIO.

To write successful scenarios, the writer should be a regular attendant of the motion picture theater, and a subscriber to the better class of the motion picture trade journals, for through these mediums the prospective scenario author can study the possibilities of scenic construction, and the attitude of the public in regard to the different classes of pictures. By consulting the trade journals in regard to past and current releases he may be saved the humiliation of duplicating some play that has already been produced. In addition to this the papers publish comments on the strength and weakness of the various films that should be of great advantage to the beginner.

The daily press abounds in suggestions for unusual or comic scenarios, for there are no more interesting or ridiculous situations than those that occur in our every day life. At the very start, the beginner should train himself to see the possibilities of a story among the newspaper items, and when one is discovered, it should be clipped and filed away for future reference, in a suitable scrap book. Never trust any little idea that may occur to you to memory, but jot it down in a note book that is devoted to your scenario "dope." If such an item is not sufficient in itself for a complete story, it may be found useful in connection with some other work.

Manuscript titles are of the greatest importance, for an attractive or unusual title has the same commercial value as a catchy advertising phrase, and often will assist in the marketing of an indifferent scenario. Commonplace titles, such as "Loved and Lost," or "Asleep at the Switch," so popular with the cheap melodramas, are not popular with scenario editors who are becoming more and more particular in this respect. A short title is the best, and should not in any case exceed five words in length.

Photoplays should contain no murder scenes, nor should they touch upon subjects that suggest crime, for films that are of a morbid nature are not wanted, either by the manufacturers or by the board of censorship. Films that have suicides or robberies for their motive will not be permitted by the censors. If a man is to be killed in your play, it should be explained in the subtitle and not shown to the audience. Any wrong that is committed in the play should be accompanied by prompt and adequate punishment, so that it will be a warning against any similar attempt at such an act. The tendency towards cleaner plays is the direct result of the constantly increasing attendance of women and children at the moving picture shows, which of course makes it inadvisable to run the old form of blood and thunder melodramas.

Pictures showing animals are always of interest, especially to children, but as there are but few manufacturers that are capable of producing such subjects, the amateur playwright should avoid introducing animals other than the dog, horse or cow. Wild animal stories are generally written at the studio of the producing company so that they will fit the resources of their menagerie. Stories that require the special training of an animal to perform some particular "stunt" are especially to be avoided. Semi-industrials, or pictures in which the plot is involved with a mill or factory are interesting but are often difficult to take and expensive to produce, for the owners of the mills are seldom enthusiastic about turning their plants into studios.

It is best to concentrate upon the affairs of every day life, rather than to soar in the clouds with complicated and difficult subjects. A story with the scenes set in a city or an every day home is of more interest to the average audience than one set in a foreign country that is unfamiliar to the average man. The picture theater patron is seeking instruction as well as amusement as a rule, and to keep his patronage he must be shown pictures that he can understand.

It is due to this fact, principally, that "Westerns" are so popular, for the characters portrayed by this class of film belong to a class that is familiar to every working man patron of the show. The scenes are homely and are

equivalent to the ordinary farm surroundings in more familiar sections of the country. Don't attempt complicated plots, nor introduce an unnecessary number of characters or scenes.

Historical pageants and plays requiring a great number of people are generally prepared by the scenario department of the producing company, as are dramatizations of well known books. Don't try to rehash the plots contained in standard works, such as Vanity Fair, Treasure Island, or Oliver Twist. Make your story original. The fewer the scenes, the better, for a play having twenty scenes or more is not only expensive to produce, but is confusing to the audience as well. Ten scenes are more than enough for any photoplay, and five are still better. Write your story in the present tense, and avoid the play of the "twenty year afterwards" type.

Comedies are the most popular type of film, for the average person attends the theater for the purpose of being amused, and the more laughs that he obtains for his money, the better he likes it. If the writer has a sense of humor and has the ability to place his conceptions in concrete form he is more certain of success than a dramatic writer of great ability. One laugh is worth fifty sobs in a film.

Real comedies are hard to find, and are correspondingly valuable to the manufacturer. The "chase around the block" pictures, and the films exploiting slap stick humor are rapidly becoming a thing of the past, and the so-called comics in which an actor in an outlandish costume knocks down everything in his path receives but scant attention from an audience that has had the opportunity of witnessing a modern type of picture.

A true comedy differs from a merely comic picture in having a series of incidents that build up to a climax, or in other words the comedy possesses a plot similar to that of a story. A comic picture, on the other hand, has a principal comic incident around which a series of events of a more or less disconnected type is woven.

The drama is second in importance to the comedy in photoplays, both in respect to its popularity and its monetary value to the scenario writer. It is in this class of scenario that the playwright must be particularly careful to avoid the restrictions placed on the several sub-

jects tabooed by the censors. This form of play has been so thoroughly worked over and exploited by the "legitimate" theater that the scenario writer will experience great difficulty in obtaining a thoroughly original theme for his story.

In the tragedy form of the drama there is always a cause, a deed, and an effect. In a photo-drama, the film must create the impression among the audience that they are witnessing the three elements of the action, unknown to the characters of the play. They should be put in the position of being at the "knot hole in the fence" at every stage in the play.

The application of the three stepping stones of the tragedy form may be had from the following conversation in which a man has a friend and informs him of a disturbance that is taking place around the corner. As they run to the scene, the friend asks, as indicated by a subtitle:

"Why are they fighting?"

"Because one of them was abusing his horse." (*Cause.*)

After reaching the scene, one of the men strikes his opponent a terrific blow that sends him to the sidewalk. (*The deed.*) During the uproar caused by this act, a policeman appears upon the scene, and places the men under arrest. The horse which has been standing unattended up to this time, now runs down the street causing further confusion. (*The effect.*)

In this homely illustration, which one would hardly call a tragedy in the ordinary sense of the word, we have not only the cause, deed, and effect, but the foundation, (introduction), the climax and the catastrophe as well. As a check to the factors just named, the story will be complete when it answers the questions, when, who, where, what, how and why. If, when going over your work, you find that these six questions are answered, you may be sure that you have at least completed the formal outline. After this the work consists of filling out or ornamenting the outline, the extent of the latter being limited only by your ingenuity.

In writing a scenario, it should be remembered that *action* is the life of the film story, and that the characters should be kept moving continuously, or the thread of the

story will be lost. Let every movement be logical, that is, keep the action close to nature. Make each character do the things that you would do under similar circumstances, and not what you think would produce a theatrical or sensational effect, that would be at variance with the natural inclinations of the character. To avoid impossible or ridiculous situations, write about that class of people that you meet in your every day life, and not those of whom you have only a reading knowledge.

Be true to your details, for a critical audience, and there are many of them now, will hold the story in contempt unless the minutest details in regard to characterization and properties are correct. In dramas of a particularly somber hue, strength is added to the play by introducing a few bright comedy touches at intervals. This contrast not only enlivens the play, but accentuates the effect of the theme. In introducing the comedy features care should be taken that no characters are used that are "lugged into the play" simply for this reason. Such characters instantly destroy the illusion that the playwright seeks to attain.

It is absolutely necessary that an idea of the scenes be given to the producing company in the scenario manuscript, for it is usually impossible to expect that the director will be as well informed in regard to the character of the surroundings as yourself. Describe the period of the play, whether modern or ancient, and give the locality in which your characters live. In indoor scenes, give an idea as to the nature of the building, the location of the doors and windows. Tell in a few words, the costumes used, both in regard to the period and their condition.

Describe when and where the characters are to enter the scene, giving the entrance, or the direction. If they are to be in the scene at the beginning of the film, state that they are "discovered," and give their position. Avoid the use of unusual furnishings if possible, for this means additional expense to the producing company, which will of course reduce the chances of having the manuscript accepted. Remember that the camera has a very limited field of view, about ten feet in the foreground. If a very great number of people are in the scene the camera must be moved back in order to cover

the scene, with the result that the figures will appear very small on the screen. Try to condense the scenes so that the characters will appear full size in the projection.

A thousand foot film runs only twenty minutes, and the play must be arranged so that it will be completed within this time. To approximate the time required to go through the various scenes, go through the play by yourself, scene by scene, timing each act by your watch. With the information gained by this method you will be enabled to make an estimate as to which scene must be "trimmed" or lengthened. The results will probably surprise you, for nearly every writer underestimates the length of his production. If you don't clip it, some one else will.

Should the action be very unusual, or the story altogether out of the ordinary, it would be well to briefly describe some of the "business" or movements of the players. With stories of ordinary life the players are in a better position to do this than yourself. Don't allow some little detail or incident to lead you astray from the main theme of your story. Stick to your story and don't ramble.

Be consistent in both your scenes and action, don't introduce wireless telegraphy in a story of Christopher Columbus, nor have a biblical character take snap shots of an aeroplane. While these illustrations may sound greatly exaggerated the writer has seen films that were fully as bad in regard to the relation between the period and action. Even the customary watchfulness of a certain director failed to stop a scene that connected George Washington and a pair of rubber boots.

Write your plays so that the pictures will explain themselves without the use of a great number of subtitles. The audience came to see pictures, not to read about them. In the few subtitles that are used, make the reading matter short, don't use a superfluous word. Avoid in particular the use of a long "leader" that gives a synopsis of the play; if your play is good it is not necessary to warn the spectators.

Subtitles must be used to show messages, and must also be used to tell the time elapsed between one scene and the next. Outside of the subtitles used for this purpose do away with as many as possible.

Do not write out of door plays in the wrong season if you wish to realize on your manuscript immediately, for it is impossible for the producing company to take toboggan pictures in June, or harvest fields in February. Interior pictures are always seasonable, for they can be taken in the studios regardless of the weather conditions. If you have an idea for an outdoor play that is out of season, write it, and file it away for use at the proper time.

Many of the larger companies have players and studios both in the east and in the west (the western studios are nearly always located in California). If your scenario treats of the Atlantic Coast, the Middle West, or the Pacific States, the producing company can stage it in that particular locality. As a rule do not show your characters in widely separated localities. If it is necessary to indicate that a man is in a foreign country, and at home in the same film, arrange the foreign scene so that it can be produced in the studio with artificial settings. This is possible when interiors are indicated, such as the interior of a hotel or office. Exterior foreign views should be avoided.

CORRECT SCENARIO FORM.

Many scenarios that would otherwise have been acceptable have been rejected because of the confusing arrangement of the manuscript, and in the lack of system on the part of the writer in displaying his wares. The film companies have neither the time nor the inclination to rewrite scenarios, no matter how good the subject. To insure the attention of the scenario editor, the following rules regarding the form of the manuscript should be observed.

(1) Write your story on good white paper, 8½x11 inches. (Typewriter second sheets will do.)

(2) Write only on one side of the paper.

(3) Use a typewriter if possible; if not, always write in ink.

(4) Write your name and address at the top of the first sheet.

(5) Write the price of your play, if you think it advisable. If it is your first scenario, we would advise the use of the sentence, "Submitted at your usual rates."

(6) In the center of the sheet about two spaces below the address, write the name of your play, capitalizing the principal words.

(7) Two spaces below the title write the word "synopsis" in capitals.

(8) On the next line begin your synopsis, giving a complete outline of your play in as brief a manner as possible. Never exceed 200 words.

(9) Two spaces below your synopsis, and in the center of the sheet, write the word "Characters."

(10) Below this title write the name, and a very short description of the characters. Only a few words of description is necessary, just enough to explain their relation to the play. Each character should be started on a separate line.

(11) Under the list of characters give the number of scenes in the play, the location of each scene (the "locale"), and whether they are to be interiors or exteriors.

(12) Begin the scenario proper on a new sheet, leaving a space of about one inch and a half at the top and a left hand margin of the same width. The margin should be left clear for the scene numbers, such as "Scene I," "Scene II," etc.

(13) Always use Roman numerals for the scenes.

(14) Subtitles should either be written even with the left hand edge of the text, or in the center of the sheet. The subtitles should always be capitalized so that they may readily be distinguished from the text.

(15) Number all of your pages.

(16) Pin the pages securely together.

(17) Never roll your manuscript, for this makes it inconvenient to handle.

(18) When submitting a manuscript always enclose sufficient postage for its return.

(19) If you have any comments to make, write them on a separate sheet of paper. Make them brief.

(20) If a scenario has been returned by one maker, rewrite it before sending it out again. Soiled copy stands a poor chance with the next producer, for it is self-evident that it has been rejected at least once during its career.

(21) Don't submit short stories, or matter in story form. Analyze the action and motive of every character.

(22) Don't write dialogues for the characters.

(23) Keep a copy of every scenario that you write, for the original manuscript may be lost in its wanderings.

(24) Don't submit the same scenario to two manufacturers at the same time.

(25) Number your scenes, and remember that every time that the surroundings or "locales" are changed you must have a new scene and a new subtitle. In moving picture plays a "scene" is the view taken at a single setting of the camera.

(26) Never leave your characters on the stage at the close of one scene, and then show them "discovered" at the beginning of the next. Have them leave before the end of the first scene, and then enter at the next.

(27) Don't attempt a play that will be likely to prove unpopular with some particular class of people. Avoid religious controversies, strikes, political feuds, etc.

The following scenario will give an idea as to the form of manuscript that is to be submitted to the manu-

facturer, showing the characters, locale, arrangement of subtitles, etc. Being merely a form of procedure, no attempt has been made to have it of any particular interest or play value.

John J. Murphy, 1008 Leland Avenue, Chicago, Ill.

(Submitted at your usual rates.)

"A STORY OF THE RAIL MILLS."

SYNOPSIS.

A mill owner, Alton Thomas, buys out one of his smaller rivals in order to control a certain class of steel. After the purchase Thomas discharges all of the former employees of his rival except the superintendent, the chemist, and the melter, who alone possess the secret of the steel. All of the old hands are replaced by men from the Thomas plant.

Among those discharged is the son of the superintendent, who unjustly accuses his father of causing his dismissal and in revenge threatens to sell the steel formula to Thomas unless he is reinstated. Fortunately for the father, the son does not know that the process of melting, which he does not understand is of as much importance as the formulae, etc., etc., etc.

CHARACTERS.

Alton Thomas, the new owner of the mill.
James McDonald, the superintendent.
Charles McDonald, son of the superintendent.
Bill McPherson, the open hearth melter.
Otto Meyer, a typical nervous German chemist (comedy).
Robert Edsall, former owner of the mill.
Hearth men, charging machine and crane operators, ingot strippers, laborers, etc.

LOCALE.

The scenes may be located in any of the steel mill districts of Pennsylvania, Indiana or Illinois.

Ten scenes are required, of which all are steel mill interiors, taken preferably on the charging and pouring floors and in the chemist's "floor" coop. This offers an opportunity of introducing an interesting semi-industrial feature, showing one stage of steel manufacture.

With the exception of Edsall and Thomas, who wear business suits of good quality, the rest of the characters wear old rough clothes. To add a realistic touch to the scenes, the lower parts of the laborers' bodies should be wrapped with burlap bandages, commonly used as a protection against the heat.

SCENE I.—Subtitle: "McDonald Warns the Melter."

Charging Floor. McPherson is directing a furnace charge. Charging machine in the foreground. Superintendent runs up the aisle, taps McPherson on the shoulder and hands him a letter. Mac reads.

Subtitle: (*Letter Form*).

"Dear Mac:—

Negotiations were closed today. Thomas will assume charge next week. McPherson and yourself will retain your old positions. EDSALL."

Both men appear to be greatly surprised and troubled. McDonald indicates that great secrecy must be observed. Orders several sacks of material to be placed in a small room at the side of furnace. Locks the door and hands keys to the melter. Melter resumes the charging operation.

SCENE II.

Chemist's laboratory. Meyer is engaged in making an analysis in the foreground. McDonald enters at right so hastily that he upsets part of the chemical apparatus. Meyer protests wildly with many uncouth gestures. Superintendent laughs and endeavors to calm the chemist, then becomes serious and shows the letter to Meyer. The chemist immediately locks up the apparatus and bolts the doors (comedy business), etc., etc.

This form while incomplete as to the story will show the method of arranging the manuscript. Nothing is left to the imagination of the producer for each movement is specified.

SELLING THE SCENARIO.

The prices paid for scenarios vary with the merit of the story, or the demand for a particular class of play. In the majority of cases, the prices range from five to thirty dollars, but in the case of exceptionally good material as much as one hundred dollars is sometimes paid. In most cases no credit is given the author, either on the screen, or in the publicity matter, unless he happens to be a well known writer of fiction.

All of the manuscript received by the producing company is first scanned by the scenario editor or his staff of readers. The duties of the scenario editor are similar of those of an editor of a magazine. When he believes that a story has merit he submits it for the further criticism of the directors and if found to be suitable, the writer will receive word that it is accepted.

Should the scenario treat of an interesting subject and contain really new ideas, though badly written, and in poor form, it may be rewritten by the editorial staff to meet the needs of the producer. We believe however, that these cases are few and far between, and do not advise that half-cooked scenarios should be submitted with the hope that they will be straightened out by the manufacturer. The scenario department is a busy one and has but little time to devote to the rehashing of amateur efforts.

When submitting a scenario fold it twice across the page and enclose it in a stout legal size envelope. Ad-

dress it to the producing company, and in the lower left hand corner write the sub-address "Scenario Department." Always be sure that enough stamps are placed on the envelope, for manuscripts that arrive at the studio with postage due are certainly not regarded in a favorable light. Enclose a fully addressed and stamped envelope for return, which should be small enough to go into the first envelope without folding.

If your story has been returned, send it to another firm immediately, and keep it moving until it has either been accepted or has gone the rounds of all the manufacturers. After a story has been rejected by everyone, look it over carefully and see if you can discover where it is wrong. If you think that you have located the trouble, rewrite it, give it another title and start it on the rounds once more. Don't be discouraged with the failure of one play, keep at it until you succeed in selling. We learn principally through our failures. It is impossible to be a good scenario writer without a very considerable amount of practice.

Lists of the producing companies may be had from the advertising pages of the motion picture trade journals. Remember that really good comedies are the rarest and most valuable material on the motion picture market.

CHAPTER V.

THE THEATER.

Unlike the "legitimate" theater, the average motion picture theater is a purely local affair, drawing the greater part of its patronage from the residents, business men, or transients passing through its immediate vicinity. For this reason the prospective owner of the theater should make a careful study of the character of the neighborhood to determine their probable likes and dislikes rather than to start out with some predetermined policy without regard to the characteristics of his patrons. Shows that are to be located in residential districts, which cater principally to women and children, require a different program and arrangement than those located in the business section of the city. A show in the business section of the town might prove a success with a saloon on either side of it, but such a location would be rather risky in the residence districts.

While many shows have proven successful on side streets and out of the usual line of traffic, due to the steady patronage drawn by an excellent show, it will usually be found a slow and difficult process to build up this clientele compared to the ease with which a theater is filled on the more prominent thoroughfares. Transients do not require the attention and special inducements that must be offered to the constant patrons, especially in cases where there are competing theaters. Neighborhood shows, especially those patronized principally by children, must have a daily change of films or suffer a loss in attendance.

Locations in the vicinity of schools or churches are usually to be looked upon with suspicion, owing to the frequent "crusades" organized against the motion-picture shows by the notoriety-seeking politicians and clergy. In some cities there are ordinances regulating the location of picture shows in regard to the schools and churches,

and the investigator would do well to look up this matter before negotiating for a lease. Similar regulations sometimes govern the proximity to parks or boulevards.

In new territory where there are no theaters, practically the only method of estimating the probable attendance is that used by the street car and interurban railroad companies, that is by counting the people passing the proposed location and dividing this number by a suitable factor, determined by experiment on other sites. This count should be made every day for a week during the time that the theater would be open, and should not be made during holidays or other times of unusual activity. The factor, or number by which the total is divided depends upon the location, the time of day, and upon the general character of the town, and varies anywhere from eight to twenty-five; that is, under ordinary circumstances, from one out of eight to one out of twenty-five of the passers-by can be depended on to enter the show.

At night, in the residential districts, this number will be from eight to ten. In mill towns having shops that run day and night the same number will probably hold true between the hours of two and five o'clock and between seven and nine in the evening. Saturday afternoons and evenings hold to the same figure in nearly any location. The purely shopping districts, while showing a smaller percentage, have the advantage of having a greater number of people passing, which of course brings the net to a considerable figure, a fair average for the factor being from ten to fifteen, between the hours of one and seven.

When there are picture shows near the site of the proposed show the matter of estimating is much simplified, for one can accurately judge conditions by taking the actual count of persons entering the show and also by the bill offered to the locality. It has been the experience of the writer that competition in a given neighborhood really increased the attendance of the first show instead of diminishing it, and that with equal conditions the second show soon reached the attendance of the first. From what I have been able to discover this was due to the fact that a man and his family could obtain nearly a full evening's entertainment for a few

cents by attending both shows, where he would not take the trouble to go to a show lasting only a short time. Should one show conflict with another in a neighborhood having a population of over five thousand, there is certain to be some fault with the program, the management, or the appearance of the unsuccessful show.

Should there be one unsuccessful show in a neighborhood that is large enough and prosperous enough to support it, it should be carefully examined for faults by the owner of the prospective theater so that he can avoid the same errors. He should note the color and decorations of the front, the arrangement of the advertising "heralds," the comfort of the seating, the ventilation and the courtesy of the cashier and manager. Next, but not least, he should note the character and condition of the films and the steadiness of the projection. If the theater in question has a sloppy, untidy front, plastered with old bills arranged in a haphazard manner, or if it has a dirty and odorous interior and uncomfortable seats, he has probably discovered one of the principal reasons why the theater is not patronized by the better class of people in the neighborhood. The solution of the difficulty is obvious.

Scratched or "rainy" films, that jiggle and jump on the screen, and frequent intermission for repairs to the film or machine, disgust the average picture show patron, who will probably never repeat his first visit. If the pictures are clean and the projection comparatively steady note whether the subject of the plays please or displease the audience, or whether the music is up to the usual standard. While making the count of the patrons see how frequently the films and songs are changed, possibly they are not changed often enough. With two adjacent shows, the matter of estimate is made much easier, for then one can compare the successful show with the failure and determine what is required by that particular locality.

It is stated by several authorities that a town of one thousand should pay from $35.00 to $50.00 per week into the ticket office, which is the same thing as multiplying the census population by 0.05. This checks very closely with the conditions in Chicago, where 400 picture shows serve a little over two million people.

When the theoretical count is checked, approximately, with the count of some theater in the locality, the expenditure necessary for building the theater and the running expenses should be considered. The rent and pay-roll are among the most important factors in well settled communities, and the prospective owner should carefully examine into these features of the expense. The current taken by the projector generally runs second in expense to those mentioned.

STARTING THE THEATER.

Before starting actual work on the theater, the builder should become thoroughly familiar with the city ordinances governing the fire risks, form of exits, etc. In addition he should carefully study the requirements of the National Board of Fire Underwriters in regard to the wiring and fireproofing of the operator's booth. In the larger cities the ordinances are very rigid in regard to the arrangement and the seating, and the smallest deviation from the prescribed construction is likely to cost the builder quite a sum of money in alterations.

In selecting a store building for a motion picture theater it should be remembered that the ceiling should be high enough to accommodate the operator's booth over the entrance and still leave head room enough so that the audience can enter without stooping. The booth should be high enough so that the light passing from the projector to the screen will not be interrupted by persons passing down the aisles to the seats. A sloping floor should be laid over the original floor of the store, so that people occupying the rear seats may have a clear view of the screen and stage. As the high portion of the false floor is in the rear of the theater and directly under the operator's booth, plenty of clearance should be allowed at this point.

As the highest part of the false floor lies from eight to ten feet back from the building line and is higher than the sidewalk line, it should be connected with the sidewalk by another floor that slopes in the opposite direction. Steps should never be used from the entrance to the sidewalk in any case, because of the danger in entering the theater in the dark and because of the danger in case of fire. They are prohibited in the majority of cities for the latter reason. The most comfortable slope

for the main floor is one in eight, or a rise of one foot in the vertical to eight horizontally.

The slope in the front of the house terminates at the stage, the latter being from three feet to four feet above the floor level. The lower edge of the screen is usually arranged so that it comes a few inches above the floor of the stage, or so that it may easily be seen by the occupants of the front seats. When the seats are ordered they should be specified for the sloping floor and the amount of the slope should also be given in the instructions. The first row of seats in front of the stage is usually set level, as this arrangement raises the line of sight and is more comfortable in looking over the front edge of the stage.

In cases where the ordinances require the upper end of the floor to be level with the side walk, it will be necessary to pull up the floor and cut through the joists, an expensive operation. With the ordinary store-room a raised floor can be constructed by placing a few trestles across the room that gradually decrease in height from the street end of the house to the stage. Joists are laid on the trestles and the flooring is nailed to the joists.

When converting an ordinary store room into a motion picture theater it is usual to remove the original glass front and its framing and install a wall a few feet back from the building line in which is placed the ticket seller's booth. On either side of the booth are placed the entrance and exit doors, which may be either of the single or double swing variety. The operator's booth is fastened inside of this wall, and a ventilation hole is pierced through it somewhere above the ticket booth, so that the operator may have a little chance at the cool, fresh air. The distance of the wall from the sidewalk line depends greatly upon the size of the theater, it being advisable to devote as much space as can be spared for this lobby, so that the patrons that are waiting for admission to the next show can be kept off the sidewalk. In the smaller shows it is seldom possible to devote more than six feet for this space, as more would seriously reduce the seating capacity.

The character of the doors and their fastenings is generally regulated by ordinance in the larger cities, both doors usually being required to open outwards so that

in case of fire they would be opened automatically by the pushing of the crowd. To prevent the crowd from entering the exit door it is usually of the single swing pattern, opening outwardly, and is not provided with hand holds on the outside. The entrance door is almost invariably of the double swing type. High partitions are placed opposite and about four feet back of both doors,

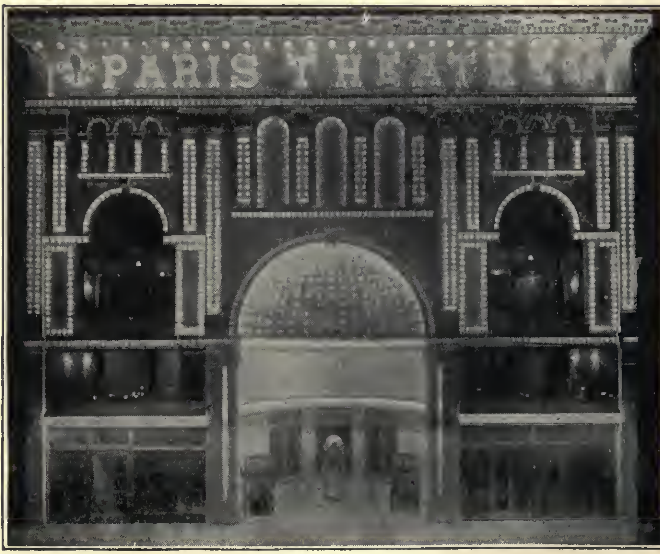


Fig. 42. Typical Theater Front.

the width being slightly greater than the width of the door, so that they will prevent lights in the street from being thrown on the screen. In some cases these walls are about six feet high, with a four foot curtain of heavy material carried on the top.

Either at the entrance door or between the entrance door and the aisle, is a chain or a movable bar that can be used to hold the incoming patrons until there is a vacant seat, or to prevent them from interfering with those passing out at the end of the show. The ticket taker is located at this point, and his position should be

arranged so that he not only controls the entrance passage but has a free view of the aisle as well.

As the operating booth is usually located over the entrance passage, in the smaller theaters, the floor of the booth should be at least seven feet above the main floor so that there is plenty of head room for those passing through the door. This booth may be either erected over the ticket seller's booth, forming a second story of the latter, or it may be an independent structure erected upon the the wall and posts extending over the passage and into the partition. Every city requires an absolutely fire-proof booth built either of sheet iron or a combination of sheet iron and asbestos, so that a film fire will be confined to the booth, at least until the audience has had time to escape. Entrance is had to the booth through a ladder, placed in a convenient place where it will not interfere with the audience or obstruct the passageways.

The booth should be at least six feet by seven, or preferably eight, for a single projector, and not less than eighteen square feet should be added for each additional machine. The height should not be less than six feet and preferably seven so as to allow a little air space over the operator's head. If the booth is sheathed with metal it should either be insulated, or the inside plastered, so that an accidental contact with a wire would not cause a fire because of a short circuit. Asbestos forms an ideal lining, as it is both fireproof and an insulating material.

A fixed booth should have a fireproof flue leading from the booth to the outside air, in case there is not sufficient window opening to obtain fresh air, this flue being furnished with a mechanically or electrically operated fan. The fresh air in this case should enter through small screened openings, at a point near the bottom of the booth through which the fan could draw at least 200 cubic feet of air per minute for each machine. These small openings, entering the theater proper, will aid greatly in ventilating the entire building.

On the auditorium side of the operator's booth there should be two openings, one for the projection of the picture, and the other for the operator so that he can view the image on the screen. All of these openings in the booth should be equipped with steel drop doors, fitted

with fusible links, so that in case of fire in the booth, the doors would be automatically dropped by the melting of the links. No opening should be unguarded by fireproof shutters. The door through which the operator has access to the booth should be provided with an automatic catch so that it will remain closed when the booth is in use. Only sheet iron fire doors should be used.

Fig. 43. An Odd Type of Theater Front.

As all film repairs and rewinding should be done outside of the booth, a separate booth is often provided for this purpose, this being fireproof as well as the operating booth. If this is not possible the rewinding must be done in the operating booth, never in the auditorium.

The chairs can either be fastened individually to the floor or fastened together in rows, in the latter case at least three of the chairs should be fastened together.

The chairs should preferably be of the opera type, which can be furnished at a comparatively small cost, and be not less than 32 inches from back to back and not less than 18 inches in width. The chair arrangement should be such that there is not less than 4½ square feet of floor surface for each occupant, to insure proper ventilation and to prevent overcrowding. No aisles should be less than three feet in width nor should the total aisle space be less than ten feet in width, for shows up to 500 capacity. This aisle width (total in case of more than one aisle) should be increased one foot for every fifty occupants in excess of 600. Fire exits should not be less than three feet in the clear.

When balconies are used they should never seat in excess of one-third of the total capacity of the theater, and should have exits leading direct to the street or alley, so that, in case of fire, the occupants of the gallery will not interfere with the exit of those on the main floor. The exits from the balcony or main floor should be not less than five feet in width, and the stairs leading from a balcony seating 150 should not be less than ten feet in width. The latter should be increased by one foot in width for every increase of fifty persons over 150.

The lighting of the theater during the performance should be accomplished so that while there is sufficient light for a patron to find his way in or out, the light should not be bright enough or arranged in such a manner as to interfere with the viewing of the pictures. All of the corridors should be so lighted that a person can easily leave the show at any time during the performance, and all of the fire escapes or fire exits should be provided with a red lamp over the opening so that it is plainly visible from any place in the theater. Eight candle-power lamps spaced along the wall at intervals of about eight feet will generally provide sufficient illumination, although this may be increased, without inconveniencing the audience, if the proper shades are employed.

The screen may be either a muslin curtain, a white painted drop, a metal surface, or a glass mirror screen, depending upon the amount of money that the exhibitor wishes to invest. The more efficient the screen as a reflector, the clearer the pictures and the less will be

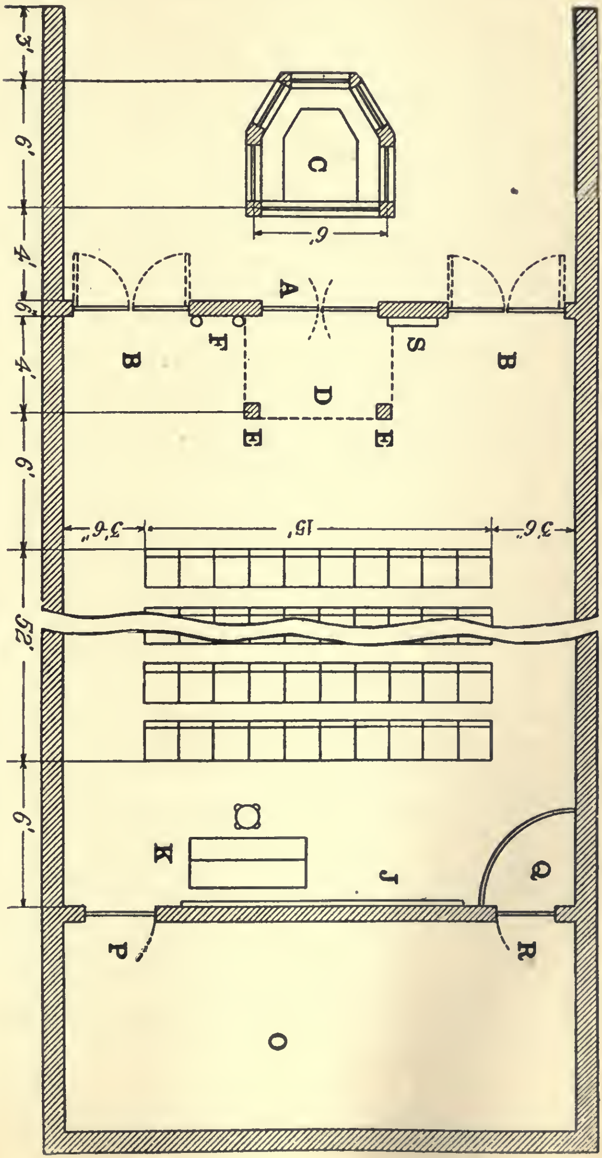


Fig. 43. Type of Floor Plan for Theater in Small Store Room.

the current consumption to obtain a given illumination. Of the screens mentioned, the muslin is the cheapest, but is also the lowest in reflecting value. A fabric curtain of muslin or painted cloth is often made necessary for the reason that it must be rolled up during vaudeville acts, which of course would be impossible with metallic surfaces or glass mirror screens.

Canvas screens covered with a form of aluminum bronze paint are very efficient reflectors and are capable of being rolled and unrolled many times without injury, providing that no wrinkles are allowed to form on the surfaces. Should wrinkles occur on a metallized screen they are much more prominent than with a muslin screen, because of the high reflecting surface. A metallized surface is much more brilliant in the high lights than a cloth screen and adds considerably to the detail in the shadows, and there is no doubt but what it adds greatly to the pleasure of the spectator for this reason.

No matter what surface is used with a rolling drop, means must be employed to fasten it securely at the sides and bottom to prevent its waving in the currents of air passing through the theater. Either a heavy pole must be used at the bottom or a tackle must be used to fasten it to the floor of the stage. The waving of a screen produces very disagreeable effects and should be reduced to the lowest possible limit. When the screens are not rolled up, the fabric may be mounted on a wooden frame and stretched tight, so that there is no possibility of movement.

Plaster screens having a dead white finish coat give good results, if kept clean, and are better reflectors of light than muslin. If the screen is to be placed flat against the wall a white finish coat can be given by the pasterers, and a black painted border run around for a frame. The border should not be neglected, for it adds greatly to the value of the projection and is effective in eliminating the ragged edge appearance of an old or patched film.

A mirror screen gives the greatest brilliancy to the picture because of its high reflecting value, and, therefore, gives better results with the same current, or the same results with less current, than the muslin or plaster

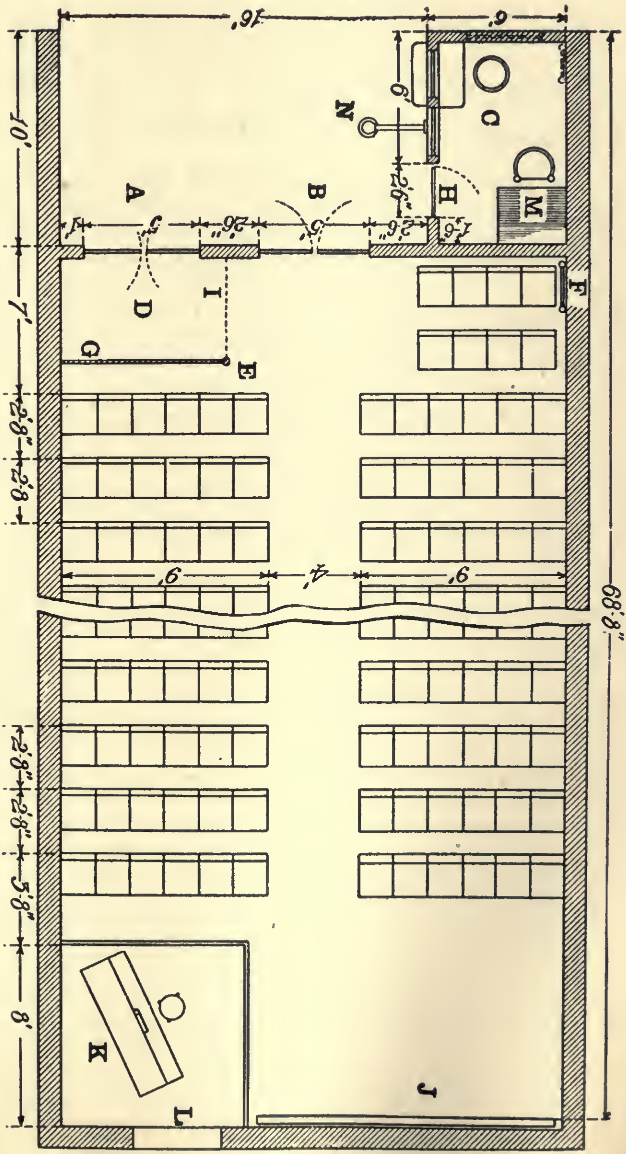


Fig. 44. Type of Floor Plan for Theater in Small Store Room.

screens. The mirror used for this purpose is of thick glass, silvered on the back, and has a ground or frosted front surface. The ground glass surface reflects a portion of the light, the balance passing through the glass to the silvered surface where it is again reflected back to the audience.

When the projector is above the center of the screen, as it generally is, and is pointed down, it is necessary to tip the screen back at the top so that the screen is perpendicular to the optical center of the projector. If this is not done, the image on the screen will be distorted, the amount of distortion being proportional to the angle made by the optical center with the screen. For the same reason, the projector should be set exactly in the center of the screen in a horizontal direction.

The construction of the ornamental "front" should be let to the concerns that make a specialty of such work, for in few cases are the local contractors capable of arranging the work artistically or even economically. It should be remembered that the appearance of the front is of the greatest importance to the exhibitor for it is from this that the customers receive their first impression of the house. It is poor economy to cheapen this part of the work, or to employ incompetent labor in its installation.

While it is not necessary to have an elaborate or highly ornamental front, it should be neat and attractive and free from the gew-gaw arrangements affected by shooting galleries, that attract an undesirable class of patrons. The cost of fronts varies as much as the cost of the buildings in which they are installed, running from $500 to as high a figure as the owner will wish to pay, these figures including the cost of the ticket seller's and operator's booths. In shopping districts of large cities, desirable fronts will probably average $2,000.

White is almost universally adopted as the color of the front, not only for the reason that it is prominent and stands out in relief against the usual dark business buildings by which it is surrounded, but because it is cheerful and pleasing, especially at night. Nothing is prettier than a well kept, clean, white show front, providing that the architecture is in keeping with the simplicity

of the color scheme. White enamel brick is a splendid material for the construction, for it is brilliant at night, is easily kept clean, and never requires repainting. A dark structure does not suggest the character of the place, and is usually passed by the transient, especially in the day time.

Bulletin boards for the "heralds" or advertising matter may be placed on the side walls or upon easels placed slightly in front of the ticket booth. Program boards giving the program of the show running at that time are usually placed on the front edge of the wall, near the sidewalk. Care should be taken in arranging the displays so that they will present a neat appearance, and because of the character of the bills this is not always an easy thing to do. Carelessly placed posters can easily ruin the architectural effect of the theater.

At night the show front should be well lighted, both by incandescent ceiling lights and by an electric sign that extends over the sidewalk. The current expended in the illumination is insignificant, when compared with the results that it brings in the way of increased patronage, especially in thickly populated districts, where there is much to distract the attention of the prospective trade. A well lighted lobby attracts more attention than all of the automatic noise makers in existence. A very simple sign is sufficient in the residential districts, where there is not so much to obstruct the view, a single word in four candle power lamps will usually be sufficient in this case. In locations where there is much light, a more elaborate sign will be required, having more lights and a more fanciful design, or one of the flashing variety that intermittently lights and extinguishes. The latter type, the "flashers," are the more expensive, as they must be provided with a motor driven switch that automatically switches the lamps in their proper relation, but are by far the most attractive.

THE AIRDOME

An airdome is simply an outdoor moving picture show that is run on practically the same lines as the old summer garden, and is therefore essentially a fair-weather show, in the majority of cases, although a few airdomes are equipped with pavillions. It is contained within a fenced enclosure, the screen being at one end of

the yard and the operator's booth at the other, the intervening space being filled with chairs and tables. Usually a stage is built in front of the screen for vaudeville or for a band.

The refreshment tables, that are occasionally in evidence in the airdome, bring in a very considerable proportion of the receipts, for the crowds seeking entertainment during the summer are far more liberal in this matter than those patronizing the theater in the winter. When refreshments are served it is either necessary to provide a pavillion for this department, or obtain the use of a building immediately adjacent to the house.

Nothing elaborate, either in the exterior or interior equipment is necessary for a successful airdome. The chairs and tables may be of the ordinary kitchen variety painted an appropriate color, and the booths merely sheds without any pretence of architectural beauty. The illumination scheme is simple, consisting of waterproof incandescent wall fixtures mounted on the fences and pavillions, or strung along weather-proof leads strung from one post to another. The ticket booth is a simple form of sentry box located at the gate.

When it possible for the owner of an existing theater to obtain a lease on a vacant lot next to his theater, it is possible for him to have an all year business, for when the weather becomes warm and the patronage of his theater declines, he has simply to move his projector into the park and continue his business in the open air. This arrangement solves the dull season problem experienced by every manager during the summer.

THE PROGRAM.

After the construction is completed, the manager will be brought to face with one of the most difficult problems met in the motion picture business, that of choosing a suitable program for an unknown audience. Nearly every theater owner has started out with the mistaken idea that he would furnish a program along some particular line, such as educational releases, travel pictures, comedy, etc., that would make his place of business "distinctive," and out of the ordinary. In his mind's eye he sees a flaming placard, such as "The House of Comedy," "The Travalogue," or some equivalent title denoting the uplift movement, or some similar interest

that he believes is shared by the majority of his future patrons. The opening night passes, and with it comes the awakening, for his pet subject has either been met with cool indifference or open complaint. The trouble has been that this man simply studied himself, and not his audience.

A first week program should be as diversified as possible, including every thing from dramas to scenics, the ultimate program being determined by a process of elimination, rather than one of construction. The taste varies with the locality, and the popularity of any one subject is soon found, if the manager will pay attention to the comments of the audience as they leave the theater. He should endeavor to connect the criticisms with the people by whom they are made, and serve the regular attendance as nearly as possible with what they require. The picture fan is the foundation of his business, and is soon lost if a competitive house opens in the vicinity that offers shows more to his liking.

An affable manager is an asset to any theater, especially in the residential districts, and if he assumes the duties of an usher, or stands at the door and greets his patrons pleasantly he has made a long step in establishing the house in the esteem of the neighborhood. By chatting casually with the members of his audience, he not only discovers their likes and dislikes, but also learns many things concerning his competitors that are often to his advantage, such as the advertising methods, songs, pleasing vaudeville acts that they have presented, or methods of reducing the cost of operation. From the same source he discovers the results of incivility among his employees, a matter to which he cannot pay too much attention.

The film exchanges, from which the exhibitor obtains his films, take all of the films from the producers that they represent, at the same price per reel, and consequently has no particular interest in picking a suitable program for the exhibitor. If the exhibitor is to receive the class of photo-plays that his audience demands, he must watch the releases carefully and see that he gets what he pays for. To keep thoroughly in touch with the new releases, the theater manager should constantly study

the motion picture trade journals and note the release dates of the films that strike his fancy. From these magazines he can obtain the story of the films and pictures illustrating the vital points in its action, and through the film records that list the plays, together with their dates, he can keep in touch with the entire situation.

In the larger cities, the film exchanges provide the exhibitor with the opportunity of witnessing the films from start to finish in their small show rooms. In this case the exhibitor is in a position to choose intelligently and list such features as may appear desirable. In the case of outlying theaters using second and third run films, it is best for the manager to visit several of the larger city theaters where he can view the films of which he has read, and listen to the comments of the audience. The attitude of the audience will prove as a guide in selecting the release and will put the exhibitor in more intimate contact with the theater-going public.

Feature films, which are unusual elaborate or extraordinary productions, generally two or more reels in length, should be carefully examined at the exchange or elsewhere before being extensively advertised by the exhibitor. While these films are energetically pushed by the manufacturers, and are often films of merit, they may not be of a class suited to the theater under consideration, and therefore should be carefully investigated by the management before devoting the evening to a multi-reel subject. When a multi-reel feature is decided upon, it should be advertised by the theater for several days in advance of its appearance, by displaying posters in front of the theater, and often by handbills. A feature film should be made a feature, and special attention should be paid to the subject of publicity.

Many theaters have "special program" night on which they exhibit one certain make of film only, regardless of the subject. A permanent announcement board at the front of the theater lists the nights on which the admirers of any one producer can view his favorite film: "Selig night, Tuesday;" "Essanay night, Wednesday," and so forth. The success of this arrangement is due to the popularity of the actors and actresses employed by the different film concerns, whom the moving picture fans regard in the same light as "matinee idols"

of the legitimate theater are worshipped. Managers of theaters that have adopted this system have noted that quite a percentage of their audiences appear only on nights when a certain make is announced.

When there are many children in the neighborhood of the theater it is advisable to try the experiment of offering some film that would interest them particularly. These films should be shown shortly after the close of school and on Saturday afternoons. Animal pictures, trick pictures, and scenics in which there is much action generally make a hit at the children's performances. Care should be taken not to make these entertainments too "high-brow," nor should dramas be included.

Whether a theater should have a vaudeville act in connection with the pictures can only be solved by experiment. Many people object strenuously to the introduction of vaudeville, as they had rather have pictures only for their money. Others are dissatisfied with the kind of program that is sometimes presented by a careless picture show manager, a condition usually found in the better class of residential districts. In our opinion it is best to exhibit pictures and pictures only, with possibly an occasional song number, than to offer a program that is cut up and lacking in character. Let the vaudeville houses run the vaudeville.

Illustrated songs are a matter of taste, some prefering the song slides and others the "spot light" singer, and as there are many large and excellent city houses employing both methods, it is hard to say which is the best. The use of song slides involves an additional expense, and additional equipment and handling in the operator's booth. In many of the larger houses it is common practice to have one or even two additional operators in the booth simply for the projection of the slides and announcements. In case it is decided to run illustrated songs, the slides may be obtained either from the film agency or from an agency that makes a specialty of song slides.

Almost any locality is capable of producing a singer or pianist for the musical features of the show at a moderate price. The salary of these people will naturally vary considerably, depending upon the size of the town and upon the local musicians' union, if there is one, the

outside limits ranging from $1 to $3 per evening. When a drummer is added to the "orchestra," he should receive the same amount as the pianist, except where the local union rules otherwise. An automatic piano or orchestrion may either be rented or bought outright, and is effective in reducing the expense in the smaller houses. In some cases these instruments are used to provide music during the intervals between the songs while the pictures are running, the pianist at this time performing other duties around the show, such as tending the ticket box or ushering. This latter arrangement is often made when the manager assumes the part of the pianist. The automatic player is also useful when the musicians fail to appear.

Vaudeville acts should be booked from a dramatic agency, which is by far the most reliable method open to the exhibitor. The cost of these acts will run from $25 for each actor per week, up to any price that the exhibitor can afford to pay. When embarking in the vaudeville line, the proprietor of the show should carefully follow the different acts that are being put on by the various booking agencies, so that this portion of the entertainment will be the best that it is possible to procure at the price. In neighborhood theaters, or where the patrons are in the habit of visiting a show more than once in a week, it is usual to present two different acts in a single week.

When the owners of two nearby theaters can cooperate with one another, or when two theaters are run by one man, it is possible for each theater to hire an act, and then exchange them in the middle of the week, thus giving each house two changes of bill each week. The same method may be adopted in handling the film.

The rental price of film varies with its age, a "first run," or new film, being the most expensive, from which point the price tapers down until the film is no longer fit for service. The price also varies considerably with the amount of competition existing between the film agencies in the town from which the film is obtained. As a rule, the cost of a "first run" film is only justified in the larger cities, where the motion picture patrons have every opportunity of seeing the latest productions

and where it would be suicidal for a shopping district show to exhibit anything but the newest features.

Except for the topicals or "weeklies," very few of the films lose interest for the reason that they are two or three weeks older than their release dates, and therefore they are as much appreciated by the audiences of the smaller communities as the subjects hot from the factory. As long as the film is clean, and whole, and without rainy spots or torn-out sprocket holes, it is good for thirty days after its release in any small town, until competition makes it necessary to book films of more recent date. After a film is more than thirty days old, it is known as a "commercial," and because of its long service, is usually in such a bad condition mechanically, that it is inadvisable to run a show made up exclusively of these films.

When three reels are run per show, one of these may be a commercial and the others not older than ten or fifteen days, this arrangement permitting a fairly good show at a small expense. One commercial in a two-reel show is too conspicuous, unless the exhibitor is fortunate enough to procure his films in a better condition than is common with this class. Two-reel, ten-day film shows are the most common in the suburban districts of large cities, two and three-reel first runs being confined strictly to the shopping and business districts. Very few of the show's patrons will put up with the continual breaking of old patches, and the jiggling and fluttering rain-streaked commercial.

When an exhibitor is paying for films less than thirty days old, he should check up the exchange so that he may be sure that he is getting what he is paying for. This may be done by means of the film records contained in the back of the motion picture trade magazines that list all of the films produced by the various film manufacturing companies, together with their release dates. One magazine in particular publishes a small film record hand-book in which all of the films are recorded in the order of their release dates, which makes it a simple matter for the exhibitor to obtain this information.

The routine of the program followed by the average picture theater is as follows:

(1) Announcements. After the lights in the audi-

torium have been dimmed, the stereopticon throws a few advertising or house announcements on the screen. These may be cards from the local merchants telling of a special line of goods or a sale, or they may be slides telling of certain features of the house management such as "Pictures Changed Daily," "Weekly Review Every Tuesday Night," or "Special Educational Release Tomorrow."

(2) Motion Picture. The first film follows the announcement immediately the last slide dissolving into the "leader" of the film, if the theater is equipped for this arrangement. In no case should a long intervening glare of light precede the picture nor should any perceptible time elapse between the slides and the film. At the end of the film it is preferable to dissolve the picture so that it gradually fades away, instead of having it come to an abrupt end with a shower of dancing spots and a glare of light.

Should the film break or some other accident occur in the operating booth, a slide should be immediately projected, notifying the audience that the show will be continued in a few moments. Announcement slides such as "Just a Moment, Please," or "Film Will Start in a Moment," can be obtained at any exchange.

While the film is being shown, the pianist or orchestra should play music that is appropriate to the picture, and not a miscellaneous medley of airs that may occur to the player as the show progresses, as it is possible to dispel the illusion entirely by the carelessness of the musician. Musical scores for nearly all of the films may be obtained from the exchanges.

(3) Song. At the end of the film the singer enters, and the first song slide is projected upon the curtain, or in case the song slides are not used, the operator trains his spot light upon the singer at the moment of entrance, being careful to follow every movement with the light. When two operators are employed, as is usually the case when song slides are used, the first re-

winds the film, and the second operates the stereopticon. With one operator, the rewinding must be postponed until the intermission. The employment of two operators is a real economy on busy nights and holidays, or in shopping district shows, as with two men the intermissions are shorter and more shows may be given in the working hours.

For the best effect, the first lantern slide should dissolve into the tail piece of the film, without intermission, an effect that is only possible by the use of two operators. At the end of the song, the motion picture machine operator projects the "leader" of the film into the last song slide which is gradually dissolved out of the field before the end of the leader.

When there is only one operator, and when a spotlight is used in place of the slides, the singer should be kept as nearly as possible in one position so that the operator will not have to be continually on the alert with the spot.

(4) Second Film. Follows in the same way that the first follows the announcement slides.

(5) Second Song.

(6) Intermission or Third Reel. At the end of the second song, or the third reel, if one is used, the stereopticon operator projects an announcement slide, "End of the Show. Those Who Have Not Seen the Entire Performance May Keep Their Seats." The auditorium lights are now turned on to full brilliancy and preparations are made for the next show.

ADVERTISING THE SHOW.

In small towns it is advisable to carry a small advertisement in the local paper, the usual cost of $1 per week for this service is usually well spent, for in these towns the subscribers read everything in the paper, including the advertisements and the ad is a constant reminder. Owing to the area covered by the large cities, to the number of shows that cater to a local trade, and to the cost of even a small card, it is seldom advisable to advertise in the daily papers of a town having more than 50.000 inhabitants, except when the show is located

in the principal shopping districts or business center. When newspaper advertising is carried, the ads should be changed frequently to keep up the interest, and if possible should give all of the coming features of special importance.

Hand bills announcing some special feature film are sometimes of value in the residence districts of large cities or for general distribution in small towns. Unless these bills offer some special treat in the way of a special program they should not be used. The expense of covering a territory by hand bills is generally somewhat greater than covering it through the local paper, and unless care is taken in the distribution, the impression given by the bills is not likely to be favorable.

Billboard service is sometimes used on special occasions, announcing a multiple reel feature film for a centrally located theater of more than local reputation. The expense of this system is considerably greater than any of those previously mentioned, and should not be undertaken by a small show. The posters may be obtained from the exchange or from the producers of the film for a nominal price.

One of the advantages of advertising in a newspaper lies in the fact that a reading notice may be obtained occasionally in the columns explaining the wonders of some new production. If carefully written in an entertaining way from the prospectus of the manufacturer, the write ups often prove a godsend to the exhibitor. An occasional biblical film, endorsed by the local clergy often brings patrons that would never have patronized the theater under other conditions. When these people discover that the show is clean and that it is attended by a good class of people they usually continue their visits.

THE TICKET OFFICE.

The regular motion picture tickets are supplied in rolls and may be obtained from the film exchange at a reasonable price. The cashier tears off a ticket for each patron, who in turn presents it to the ticket taker in the theater. The tickets are a check on the paid admissions, and if carefully used will prevent many leaks in the financial end of the show.

The number of tickets in the ticket taker's posses-

sion represents the amount of money received by the cashier, and should therefore be equal to the number of the end ticket on the roll before the show, subtracted from the number on the end ticket after the show. There are devices now on the market that in a way resemble a cash register, that afford an absolute check on the number of tickets sold. These are metallic boxes containing one roll of tickets that can only be unlocked by the manager's key. The ticket is issued to the patron by pressing a lever that cuts off the ticket and at the same time registers the transaction on a counting mechanism on the inside of the machine.

If the color of the tickets is changed day by day, it is almost impossible for anyone to enter without paying, or by discarded tickets from the day before. To prevent the tickets from being used a second time a "ticket chopper" may be used that mutilates the ticket in such a way that it is impossible to present it without detection. As these machines are quite expensive, their use is usually confined to the larger shows. In any case the manager should burn the tickets taken from the ticket box at the end of the day's performance, to prevent a second admission on one ticket. As a further check on the ticket system, the manager should occasionally count the house during one or more performances and compare the results with the ticket numbers in the ticket taker's box.

PROFITABLE SIDE LINES.

In many cases the theater owner can increase his profit over the amount received from the admissions by carrying local advertising for groceries, drug stores, or other business establishments in the neighborhood. While the patrons will not object to a limited amount of this sort of display, care should be taken so that the advertising idea does not become one of the most prominent features of the show. It is best to limit this display to a short time during the intermission only, and not after the theater is darkened for the show.

When advertising slides are projected on the screen just before the first film, particular care should be taken not to take too much time, as the audience is naturally anxious for the show to begin and does not take kindly to any interruption of this nature. Three slides should

be the limit in any case, and they should be of an interesting and artistic nature, never of the home-made handwritten type. The cost of the slides should be met by the advertisers. In neighborhood shows, the slides should be changed at frequent intervals to prevent their "going stale."

When a drop curtain is used to cover the screen during the intermission, it may be used to display a number of advertisements. The same method can be applied to the street scenes used in the vaudeville show, if one is contemplated in connection with the pictures. By the combination of the drop and the street scenes it is possible to accommodate a number of advertising clients, and this should bring a considerable revenue to the show. Like the slides, the drop advertising should be changed occasionally, so that the interest will be maintained.

Program advertising is possible with the majority of theaters seating five hundred or over, and this is practically the best form of display, since the program is useful to the patrons of the show and for the reason that many of the pamphlets are carried home for future consultation. In this way the theater can obtain its program free and usually with a fair margin of profit over the printer's bill.

In addition to the advertising, many theaters make a practice of selling candy during the intermission. In the majority of cases this proves a nuisance to the audience, unless the management is fortunate enough to secure a vendor or "candy butcher" that can make his sales patter entertaining. After visiting many of the principal theaters in Chicago, the writer can remember only two instances in which the vendor proved anything but a nuisance to the audience. Either stay in the motion picture business or go into the candy business; don't mix them.

CHAPTER VI.

THE PROJECTOR.

While the elementary details of the projector and its development were given in Chapter I, it is the purpose of this chapter to enlarge on the description previously given so that the reader may become familiar with the actual operation and maintenance of the machine, and the theory of its optical system. The constantly increasing list of projectors being placed on the market prohibits an extended discussion of the constructional details and adjustment of every machine, within the limits of this book, but as they are all built on the same basic principles we will confine ourselves to those parts that all machines have in common, leaving the solution of the minor variations to the ingenuity of the reader.

THE OPTICAL SYSTEM.

As shown in Chapter I, the optical system consists of two principal groups of lenses known as the objective and the condenser. It is the function of the condenser lens to gather as much light as possible from the lamp and to concentrate it upon the small area occupied by a film picture, thus increasing the intensity of illumination on the film. As the condenser lens receives light from the lamp over its entire surface, and has many times the area of the film image, it is evident that the original surface illumination will be increased on the film in direct proportion to the reduction of area, since the same number of rays are crowded into a smaller space.

After passing through the film, where it is broken up by the dark and light portions of the film image, the light passes through the objective lens in the form of a double cone, whose apex is near the center line of the objective. From the objective the shadow of the film is projected direct to the screen. As the rays of light

cross near the center of the objective, the image received by the objective is inverted on the screen, so that the film image must be turned upside down if the image on the screen is to appear in its correct position. Since the cone of light from the objective to the screen is much longer than the cone from the film to the objective the image is much enlarged on the screen, the angle of both cones being equal. The film lies between the condenser and objective at a distance that is fixed by the curvature of the lens surfaces.

THE CONDENSER LENS.

The condenser is built up of two separate lenses, of the "plano convex" type, the convex surfaces of which are brought face to face with one another in the inside of the container, leaving the straight faces directed toward the lamp and objective respectively. The lens next to the lamp is called the "back" condenser and the lens next to the film the "front condenser." The back condenser receives the light rays from the lamp and straightens them into a band of horizontal and parallel rays. Entering the front condenser as parallel rays, they are bent into a cone of light whose apex lies on the center line of the lens (optical center), and at the focal center of the objective. The exact distance of the apex of the rays on the optical center depends on the curvature given to the lens.

For a sharp picture, the film must occupy a fixed position in regard to the condenser and objective lens, as before stated, the distance between the film and the apex, or point of convergence of the light rays, being known as the *"focal length"* of the lens. This distance is selected in the motion picture projector so that the film is much closer to the objective than to the condenser. The focal length of the back condenser lens determines the distance of the lamp from the lens, the focal length ranging from 4½ inches to 8 inches in the majority of cases. Back condensers of short focal length necessarily bring the lamp very close to the glass and increase the danger of breaking the glass through the heat of the arc, but give the advantage of increasing the brilliancy of the image on the screen. Since a short focus condenser lens is thicker than one of long focus, the chances of breakage are still further increased.

With a long focus back condenser, the distance from the lamp is greater, and the glass thinner, but has the disadvantage of reducing the illumination on the screen, since less light falls on the surface of the lens. In practice a compromise is made between the intensity of the illumination and the danger of heat breakage, which brings the focal length from 4½ to 8 inches (average 6 inches). When a very short focal length is used, it is much more difficult to keep the lamp in focus, as a very small variation in the lamp distance makes a great difference on the screen, much greater than with a lens of longer focal length.

As the objective lens and film is at a greater distance from the condenser than the lamp, the front condenser is of a longer focal length than the back condenser, and is, therefore, much thinner in section. Its focal length should be such that the apex of the rays comes exactly at the focal center of the objective lens. The difference between the focal length of the two condenser lenses should not be made too great, as this makes the lamp adadjustment difficult. The usual focal length of the front condenser is 14 inches or less, this distance being equal to the focal length of the objective lens plus the distance from the film to the center of the condenser case.

Another factor regulating the size of the condenser lenses is the diameter of the light cone at the point where it passes through the aperture of the film gate, it being evident that the diameter of the light cone at the aperture should be at least equal to the length of a diagonal drawn from one corner of the aperture to the other. As this opening is nearly equal to the size of the film picture (¾x1 inch), the diagonal is approximately equal to 1¼ inches, which should also be the minimum diameter of the light cone at this point, if the light is to entirely cover the picture. With the focal length of the condensers determined on, the cone diameter regulates the diameter of the lens, as the lens must be at least equal to the diameter of the cone at the condenser.

The diameter of the condenser lens can be found by a simple arithmetical proportion between the aperture diagonal, the focal length of the objective lens, and

the distance between the focal center of the objective to the face of the front condenser.

By letting A represent the focal length of the objective B=1¼ inches (length of aperture diagonal, and C= the distance from the focal of the objective to the front face of the front condenser, we have $\frac{BC}{A} = \frac{1.25C}{A}$ = diameter of condenser.

In a machine having an objective with a focal length of 4 inches, and C = 12 inches, we apply the formula as follows:

$\frac{1.25x12}{4}$ = 3.75 inches, the minimum diameter of the condenser lens. The next larger commercial size should be chosen, when the result does not come out in even figures. While the aperture was given equal to the size of the film picture to simplify the calculations, it is usually 1-16 inch smaller in each of the dimensions, making the actual opening 11-16 x 15-16 inch. This is an error on the safe side in making the calculations.

When the condenser lens is too small in diameter and does not completely cover the picture, there will be dark corners on the screen. This may be remedied by moving the motion head, containing the objective and film, closer to the condenser, when it is impossible to secure suitable condensers. This has the fault of throwing the apex of the light cone ahead of the focal center of the objective.

THE OBJECTIVE LENS.

The objective lens generally consists of four individual lenses assembled in a brass tube, two of the glasses being in front of the tube and two at the back, the two containing spaces at the ends of the tube being known as the "cells." The two front glasses are cemented together with some transparent cement such as Canada balsam, while the rear assembly is held apart by means of a brass spacing ring. The lens is not reversible and should be arranged so that the spaced glasses are always next to the film. The accuracy of this lens is of the greatest importance, even more important than the accuracy of the condensers, as there can be no further correc-

tions to the light after passing the front cell, and as there is no intervening film to modify imperfections in the grinding or glass, as in the case of the condensers

A correctly designed lens is free from the distortions that are always in evidence in the cheaper grades of optical apparatus, such as chromatic dispersion, astigmatism, and the curvature or distortion of the straight lines in the picture. The first lens error mentioned above, chromatic dispersion, results in the light beams being broken up into their elementary components of red, yellow, green and blue rays, these colors appearing at the edges of the objects on the screen as a fringe, on sharp edges or between strongly contrasting parts of the image this distortion appears like a rainbow, such as may be seen by looking through a glass prism. A lens that is constructed so that the field is free from color is known as an *achromatic* lens, a type that is absolutely necessary for clean projection.

Usually this correction is accomplished by building the lens up in two or more parts, each alternate lens being of a different grade of glass, having a different refracting power. The two glasses most commonly used for this purpose are known as "Crown" and "Flint" glass, the first material mentioned corrects the chromatic dispersion of the other as the light passes through the lens. This accounts for the two glasses in each end of the tube, each of the two groups being independently achromatic.

An *anastigmat* lens is built to overcome the error known as "astigmatism," a condition in which all of the rays are not brought into focus at a common point. When astigmatism exists, all of the rays do not cross the optical center of the lens at a common point (at the apex of the light cone), and, as a result, a ray passing from the lens does not fall on its proper place on the screen. A ray from an anastigmat lens (corrected) is truly circular at all points in its length, while an astigmat lens (not corrected) gives a cross section varying from a vertical ellipse to a horizontal ellipse, passing through an intermediate form similar to a cross. The correction for astigmatism is made in the curvature of the lens face or by introducing supplementary lenses having different face curves.

A *rectilinear* lens avoids what is known as "barrel" or "pin-cushion" distortion, that is, it projects a straight line on the film as a straight line on the screen. If the lens is not truly rectilinear, the edges of the film aperture will be curved, either out or in, as will be all of the straight lines in the picture, the curvature increasing as the edge of the picture is approached. This distortion is at a maximum with a single lens having a diaphragm or reduced opening, such as the gate aperture. If a single lens were used with the aperture between the source of light and the lens, "barrel distortion" would result, that is, the edges of the picture would curve outwardly giving it the appearance of a barrel. Placing the restricted opening behind the single lens would make all of the straight lines bow in, an outline similar to that of a stuffed pin-cushion.

By providing a double lens, in which one lens rectifies the distortion of the other, we can obtain a straight line on the screen, this combination of two lenses at opposite ends of the lens tube being known as a "rectilinear lens."

For a perfect projection the lens must overcome all of the difficulties mentioned that are inseparable with a single group of lenses, as shown at either the front or back. With the arc out of its proper position the most perfectly ground lens is incapable of avoiding these distortions.

When the film picture is not brought central with the optical center of the lens, the corners of the image are usually dark on the screen, as the picture or a portion of it is out of the included angle of the light cone. When the lens is shifted to correct this condition, the sides of the image become inclined with one another giving what is known as a "keystone" picture, even with a rectilinear lens. To avoid the keystone picture, the angle of the lens must be sufficiently great to bring in the edges.

LENS CALCULATIONS.

Because of the great difference in the size of theaters it is impossible for the makers of the projector to furnish a single objective lens that will fill all requirements, so that it is necessary that the lens be calculated

in each case to obtain the specified results. The distance from the lens to the screen, re-called the "throw," the size of the required picture, and the focal length of the objective are the factors involved in fitting the lens to any given theater.

The length of throw is governed by the location of the projector in regard to the screen, and is measured in feet along the line of the optical center of the lens. If the projector is raised for any considerable distance above the center line of the screen it will not be sufficient to measure the distance along the floor horizontally as the slanting center line of the lens will be greater than the horizontal distance. This error will not be excessive, however, if the vertical distance from the center of the screen to the center of the lens does not increase at a rate greater than one foot for every ten feet of throw.

With a given focal length of lens, the size of the picture on the screen increases with every additional foot of throw, since the distance across the angle of the light cone is greater at an increased distance from the lens. With a given throw, the size of the picture decreases —with an increase in the focal length of the lens, and vice versa. The size of the picture is generally determined by either the width of the theater or by the height of the ceiling, or in some cases by the amount of light that can be generated in the lamp. For every increase in the area of the screen image there must be an accompanying increase in the amount of light generated, if the illumination of the screen is to be equal in both cases. Doubling the area of the screen requires double the light with equal screen brilliancy.

In estimating the size of the screen it should not be forgotten that the proportion between the length and height of the screen must be the same as the proportions of the film picture, and that it is impossible for the lens to change this relation. As the film picture is ¾x1 inch, the height of the picture is three quarters of the length, a proportion that must be followed on the screen. If the image on the screen is to be 12 feet long, the height will be ¾ of twelve, or 9 feet, a figure that cannot be changed unless part of the picture is trimmed from the screen. The fact that the aperture plate is 1-16

inch less than the film picture in each dimension does not change the proportions of the picture to any great extent.

When stereopticon slides are to be used the proportions of the picture are changed, as the stereopticon slide is more nearly square, necessitating a higher screen than that used with the motion pictures. The size of a standard slide is usually taken as being 2¾x3 inches, although many slides are larger than this. The outside dimension of the American standard slide is 3¼x4, and the foreign slide is 3¼x3¼ inches, the actual picture space being practically the same in both cases, because of the binding or blank margin.

The actual screen should be larger than the picture allowing for a suitable margin all the way around, and the margin should be painted black so that any overhanging parts of the screen image will be invisible to the audience. When the screen is exactly the size of the picture, an unevenly centered slide or film will run over the edge of the screen giving a very untidy appearance, and creating a bad impression in the minds of the audience.

As explained in a preceding paragraph, the focal length of the objective lens is approximately the distance from the film to the focal center of the lens, a point near the center of the lens tube, or midway between the two glasses. This measurement is accurate enough for the calculations made in determining the size of lens. The real focal length is just a little shorter than this. With a given lens the focal distance may be measured by turning the end of the lens toward the light of a window and then placing a white card or piece of paper near the back of the lens. By moving the paper back and forth a point will be found at which the lines of the window frame appear sharp and distinct. With the paper in the latter position measure the distance from the center of the lens tube to the paper; this is the focal length of the lens.

The relations between the focal length, throw, and picture size, are shown by the accompanying table from which the data may be readily obtained without calculation. The equivalent focal length of the lens is given in the first left hand column. Arranged horizontally across the top of the table are the throws ranging from 15 to 100 feet. In the body of the table to the right of

the focal length column and below the line of throws are the picture sizes that correspond to the values given by the two columns. It will be noted that there are two different figures given for the screen size opposite each value of the focal length, that give the length and height

TABLE SHOWING SIZE OF SCREEN IMAGE WHEN MOTION PICTURES ARE PROJECTED.

Size of mat opening 11/16 by 15/16 inch.

Equiv. focus Inches	15 ft.	20 ft.	25 ft	30 ft.	35 ft.	40 ft.	45 ft.	50 ft.	60 ft.	70 ft.	80 ft.	90 ft.	100 ft.
2⅛	4.8	6.4	6.0	8.9	11.3	12.9	14.5	19.1					
	6.5	9.7	11.0	13.2	15.4	17.9	16.9	22.0					
2½		5.4	9.6	8.2	9.6	10.9	12.3	13.7	16.4				
		7 4	9.3	11.2	13.1	14.9	19.8	19.7	22.4				
3		4.5	5.7	6.8	8.0	9.1	10.3	11.4	13.7	16.0			
		6.2	7.7	9.3	10.9	12.4	14.0	15.6	16.7	21.8			
3½			4.9	5.9	6.6	7.9	8.8	9.6	11.7	13.7	15.7		
			9.6	8.0	9.3	10.6	12.0	13.3	16.0	18.7	21.4		
4			4.2	5.1	6.0	6.6	7.7	8.5	10.3	12.0	13.7	15.4	
			5.8	7.0	9.1	6.3	10.5	11.6	14.0	16.3	19.7	21.0	
4½				4.5	5.3	6.2	6.8	7.7	9.1	10.6	12.2	13.7	15.4
				6.2	7.2	6.4	9.3	10.5	12.4	14.5	16.6	19.7	21.0
5					4.8	5.4	6.1	6.8	8.2	9.6	10.9	12.3	13.7
					6.5	7.4	8.4	9.3	11.2	13.0	14.9	16.6	18.7
5½					4.3	4.6	5.6	6.2	7.4	8.7	9.9	11.2	12.4
					5.9	8.7	7.6	8.4	10.2	11.6	13.6	15.3	17.0
6						4.5	5.1	5.7	6.6	8.0	9.1	10.3	11.4
						9.2	7.0	7 7	9.3	10.9	12.4	14.0	15.6
6½							4.7	5.2	8.3	7.3	6.4	9.6	10.9
							6 4	7.1	9.6	10.0	11.4	13.0	14.5
7							4 4	4.9	5.6	6.8	7.6	8.6	9.8
							6.0	6.9	6.0	9.3	10.9	12.0	13.3
7½								4.5	5.4	9.4	7.3	6.2	6.1
								6.2	7.4	6.7	10.0	11.2	12.3
8									5.1	6.0	6.6	7.7	6.5
									7.0	9 1	9.3	10.5	11.6

Fig. 45.

of the projection. The upper figure of the pair gives the height of the picture and the lower gives the length.

Thus the picture size given by a lens having a focal length of four inches gives a picture 6 feet in height by 8.1 feet in length, with a throw of 35 feet. Combinations giving a picture length less than 7.0 feet are omitted

from the table as a picture having length less than this is not suitable for public exhibition, especially with the longer throws. By examining the table it will be seen that the picture size diminishes with an increase of focal length with a constant length of throw. With a given focal length, the picture size increases with an increase of throw.

When the size of the picture and the length of the throw has been determined, the operator can find the necessary focal length of the lens by starting at the top of the table and following down the column under the head giving the throw, until a picture size is found that approximates the desired size.

Example.—In a certain theater it is necessary to have a throw of 70 feet. The picture is to be, as nearly as possible, 8 feet in height by 12 feet in length. Find the focal length of the lens necessary for this condition.

Solution.—Under the heading "70 feet," follow down the column until the nearest picture size is found, which is in this case 8.7x11.9 feet. From the figure giving the height of the picture (8.7 feet) follow along this line to the left to the equivalent focus column where it will be found that a lens having a focal length of 5½ inches will be required.

The table is reversible, that is, it may be used to find the picture size with a given lens and throw, or it may be used to find the throw necessary to obtain a picture of the given size with a given lens. Both of these calculations will prove of use to the operator of a traveling show or lecture tour who is continually meeting with widely varying lengths of throw, and who is seldom blessed with more than one objective.

Example.—A projector has a lens of 4¼ inch focal length, and is installed so that the throw to the screen is 50 feet. Find the size of the picture.

Solution.—From the figure 4½ in the left hand column follow across the page to the right until in the column marked "50 feet." The picture size will be found given as 7.7x10.5 at the intersection of the horizontal lines and the column.

When the length of throw is required that will give a certain size of picture with a given focal length, start with the focal length in the left hand column and follow

to the right until the required picture size is found. From the latter figure trace up the column to the figure given in the heading. This will be the required throw.

SIZE OF LANTERN SLIDE SCREEN IMAGES.

Size of Mat Opening 2¾x3 inches.

Equiv. Focal Length Ins.	Length of Throw (Feet)												
	15	20	25	30	35	40	45	50	60	70	80	90	100
5	8.0	10.8	13.5	16.3	19.0								
	8.8	11.8	14.8	17.8	20.8								
5½	7.3	9.8	12.3	14.8	17.3	19.8							
	7.9	10.7	13.4	16.1	18.8	21.6							
6	6.6	8.9	11.2	13.5	15.8	18.1	20.4						
	7.3	9.8	12.3	14.8	17.3	19.8	22.3						
6½	6.1	8.2	10.4	12.5	14.6	16.7	18.8						
	6.7	9.0	11.3	13.6	15.9	18.2	20.5						
7	5.7	7.6	9.6	11.6	13.5	15.5	17.5	19.4					
	6.2	8.3	10.5	12.6	14.6	16.9	19.0	21.2					
7½	5.3	7.1	8.9	10.8	12.6	14.4	16.3	18.1					
	5.8	7.8	9.8	11.8	13.8	15.8	17.8	19.8					
8		6.6	8.4	10.1	11.8	13.5	15.2	17.0	20.4				
		7.3	9.1	11.0	12.9	14.8	16.6	18.5	22 3				
8½		6.2	7.9	9.5	11.1	12.7	14.3	16.0	19.2				
		6.8	8.6	10.3	12.1	13.9	15.6	17.4	20.9				
9		5.9	7.4	8.9	10.5	12.0	13.5	15.1	18.1	21.1			
		6.4	8.1	9.8	11.4	13.1	14.8	16.4	19.8	23.1			
9½		5.6	7.0	8.5	9.9	11.4	12.8	14.2	17.1	20.0			
		6.1	7.6	9.2	10.8	12.4	14.0	15.5	18.7	21.9			
10		5.3	6.6	8.0	9.4	10.8	12.2	13.5	16.3	19.0	21.8		
		5.8	7.3	8.8	10.3	11.8	13.3	14.8	17.8	20.8	23.8		
12			5.5	6.6	7.8	8.9	10.1	11.2	13.5	15.8	18.1	20.4	
			6.0	7.3	8.5	9.8	11.0	12.3	14.8	17.3	19.8	22.3	
14				5.6	6.6	7.6	8.6	9.6	11.6	13.5	15.5	17,5	19.4
				6.2	7.3	8.3	9.4	10.5	12.6	14.8	16.9	19.0	21.2
16					5.8	6.6	7.5	8.4	10.1	11.8	13.5	15.2	17.0
					6.3	7.3	8.2	9.1	11.0	12.9	14.8	16.6	18.5
18					5.1	5.9	6.6	7.4	8.9	10.5	12.0	13.5	15.1
					5.6	6.4	7.3	8.1	9.8	11.4	13.1	14.8	16.4
20						5.3	6.0	6.6	8.0	9.4	10.8	12.2	13.5
						5.8	6.5	7.3	8.8	10.3	11.8	13.3	14.8
22							5.4	6.0	7.3	8.5	9.8	11.0	12.3
							5.9	6.6	7.9	9.3	10.7	12.0	13.4
24								5.5	6.6	7 8	8.9	10.1	11.2
								6.0	7.3	8.5	9.8	11.0	12.3

Fig. 46.

Example.—It is necessary to obtain a picture approximately 9x12 feet with a lens having a focal length of 4 inches. Find the throw.

Solution.—Starting with 4, the focal length of the lens, in the left hand column, follow along a horizontal line to the right until the nearest size of picture is found, which in this case will be 8.5x11.6. Follow this column to the top where it will be found that 50 feet is the required throw.

When stereopticon slides are to used, the height of the screen will be much greater in proportion to the length, so that a separate table must be used that will take the size of the slide into consideration. The height of the slides really determines the height of the screen, when both classes of picture are used. This data is given in a second table headed "Screen sizes for Lantern Slides" which is used in exactly the same way as the table of motion picture projection.

When the factors in the table do not exactly coincide with the given quantities, and when the lens determinations are to be made more accurately than can be taken from the tables, the following rules may be used:

Picture Height is equal to the height of the aperture (11/16 inches) multiplied by the throw, the product being divided by the focal length of the lens. All dimensions are to be in inches.

Picture width is obtained by multiplying the aperture width (15/16 inch) by the length of throw, the product being divided by the focal length of the lens. All dimensions to be in inches.

The focal length of the lens is equal to the film aperture width (15/16 inch) multiplied by the throw, and divided by the required picture width. Dimensions in inches.

Throw is equal to the width of the desired screen picture multiplied by the focal length of the lens divided by the film aperture width. Dimensions in inches.

These rules are approximate, to avoid the use of more complicated calculations, but are accurate enough for the purpose for which they are intended. The maximum variation from the actual figures will not exceed one inch, a negligible quantity in this work. These rules are worked out from a simple arithmetical proportion that reads as follows:

Focal length : Throw :: Film picture : Screen image.

ADJUSTABLE LENSES.

The focal length and picture size can be changed on some lenses by turning the front cell by the rim, which of course moves the front lens in or out, according to the direction of rotation, and changes the relative position between the front and rear glasses. By this means

it is possible to secure quite a variation in the size of the image for a given throw, in some cases nearly 40 per cent. These are special lenses and quite expensive. A slight reduction in the picture size can be made in any lens by unscrewing the front lens, but this procedure does not usually result in the best class of projection.

MATCHED LENSES.

When the projector is to be used for projecting both motion pictures and slides, the condition in the majority of cases, it is provided with two lenses placed side by side, one being used for projecting the slides and the other for the film. These lenses are matched or designed so that they both give screen pictures of the same width or area on the screen with the same throw, notwithstanding the difference in the size of the film picture and the slide, or the difference in their proportion.

If the screen is made in the proportions of the motion picture, it is evident that the slide image can be no higher than the height of the motion picture, which of course results in a narrow slide image. Since the latter is of less area than the film picture, owing to its smaller width, it will be much brighter with slides having an equal density. With images of equal area the slide will be much higher than the film image but will be of the same brightness.

For equal heights of picture, the stereopticon lens, or "Stereo" lens as it is called, must have a focal length of 4.00 times the focal length of the motion picture lens. For equal areas, the stereo lens should have a focal length of 3.60 times the focal length of the motion head lens. The same lamp house and condenser lens serves both the motion head and stereo lens.

FOCUSING THE PICTURE.

In focusing, the optical system of the projector is adjusted so that a bundle of light rays issuing from the objective lens converge into a single spot on the screen, giving a sharp and distinct image of the film picture or slide. The point at which the rays meet and form the point of focus depends upon the distance of the film or slide from the optical center of the objective lens, so that by properly adjusting the lens in regard to the film, this condition of the light rays may be made to occur at al-

most any point along a center line that passes through the center of the lens.

In the actual projector, the objective lens is made so that it can be moved back and forth, for a limited distance in a sliding collar that surrounds the lens tube. If the distance from the lens to the screen, or the distance from the film to the lens is altered, the lens can be moved so as to accommodate the new condition and again bring the light rays into a single point of convergence on the screen.

When the screen lies on either side of the point of light convergence, the picture will be hazy and indistinct because of the multitude of rays making individual impressions over a perceptible area. When the lens is too far from the film, the point of convergence will be between the screen and the lens. When the lens is too far from the film, the point of convergence will lie beyond the screen. The best point of focus for the clearest picture is found by experiment, or by moving the lens tube back and forth until the best image is found.

Without an anastigmat lens it is impossible to obtain a sharp picture all over the screen, as from a previous explanation, it is impossible for an ordinary lens to bring all of the rays to a point of focus at the same time. With an astigmat lens or a lens that has not been corrected for this fault, the blurred or out-of-focus portions of the picture occur as streaks, some times radiating from the center of the screen, and sometimes appearing as circular arcs, depending upon the nature of the lens curvature. The prominence of the uneven focus depends a great deal upon the nature of the film or slide, sharp, clear cut, and contrasty slides showing the defect more clearly than those having a more uniform density.

With cheaply constructed lenses, the focal points of all rays do not fall in the same plane, and, therefore, do not coincide with the flat surface of the screen, causing the image again to be out of focus on certain portions of the screen. The focal points in such a lens lie on the surface of an imaginary sphere whose center is the optical center of the objective lens, the image, of course being curved, would necessarily have to be projected on a spherical screen of the same radius, if all of the portions were to be obtained in perfect focus. To

do away with the curvature entirely requires a special lens, composed of many individual glasses, and therefore would be far more expensive than the usual lens. In practice the lenses are not completely corrected for spherical aberration, so that it is necessary to strike a compromise between the focus at the center of the picture and that at the edges, a proceeding that is hardly noticeable to the average spectator. A lens that projects the image without the error due to curvature is said to have a "flat field." Theoretically the field is never entirely flat.

For perfect focus with any lens the screen must be perpendicular to the optical center of the lens. If this is not the case, the focal points at the nearest edge of the screen will lie behind the nearest edge of its surface, and will be in front of the surface at the farthest edge. When a screen inclines to the light rays in this manner, only those near the center will be in focus. In nearly all theaters it is necessary to install the projector above the level of the screen, so for this reason it should be tilted back at the top so as to meet the optical center of the lens at right angles. In some cases the projector lies to one side of the vertical center of the screen, so that it is not only necessary to tilt the screen back at the top, but to move one of the vertical edges forward as well, so that it is perpendicular to the light rays in both a horizontal and vertical sense.

When the projector is tilted, without tilting the screen to a corresponding degree, the picture will not only be impossible to focus properly, but will be distorted in outline as well, that is, the sides of the image will be inclined with one another, making the top of the picture narrower than the bottom. This distortion makes what is known as a "keystone" picture which is due principally to the fact that the top of the screen is nearer the picture than the bottom. As the picture widens with every increase in distance between the projector, the bottom will be increased in width. With the projector installed at one side of the screen, the keystone effect will be horizontal instead of vertical, the top and bottom lines in this case will slant together the nearest edge being the smaller.

When it is necessary to have a vertical screen with an elevated projector, the keystone effect may be over-

come, with small angles, by setting the slide or picture aperture eccentric with the lens. In this case the projector is no longer tilted so that its optical center meets the center of the screen, but is set perfectly horizontal so that the beam of light is deflected entirely by the eccentricity of the lens. In practice this effect is obtained by moving the lens, rather than the aperture or slide. The eccentric lens is really preferable to the inclined screen, for if the screen is at a considerable angle with the line of sight of the spectators, the angle made with the line of vision in itself is conducive to a keystone effect, as the bottom of the screen is nearer the audience than the top by the amount of the inclination. The distortion due to the latter effect is much less however than that due to the angle of the projector with the screen, since the audience is already at an angle, even if the screen were perpendicular, for the reason that they are seated below the center of the screen.

LAMP ADJUSTMENT IN REGARD TO THE LENS.

In general, the source of light should lie on the optical center of both the condenser and objective lenses so that the light rays will be bent through equal angles through the condensers. The position of the light therefore governs the uniformity of light distribution on the screen and the definition of the picture. This is without regard to the light used whether kerosene, calcium or electric, the light in the sense that it is applied to the lens means a single point from which the light emanates, independent of the nature of its source.

The brightest spot of the source must be brought to the center of the screen when the source occupies more than the theoretical point, as is always the case in practice. With the film or slide removed, an image of the arc or flame may be thrown on the screen where it will appear in an inverted position as in the case of the slide or film. If the bright spot is found out of the center by this means, the lamp must be moved in the opposite direction from that which appears on the screen. If the bright spot appears above the center of the screen, the lamp should be moved up instead of down as would appear to be the case. All projectors are provided with a rack and pinion adjustment by which the lamp may be raised or lowered without opening the lamp house.

In the figure at the upper left hand corner of Fig. 47 is an effect produced by an eccentric lamp position, the shadow is at the right and the bright spot at the left. Owing to the inversion of the image, the lamp should be moved to the left to correct the shadow. In the next figure the lamp position is at the opposite side of the optical center, which of course requires a right hand movement of the lamp. In Fig. 3 the lamp is too high and should be lowered. Fig. 4 is a reverse case in which the lamp should be raised. In Fig. 5, the lamp is too near the condenser. In Fig. 6 it is too far from the condenser. In Fig. 8 the lamp is in the correct position.

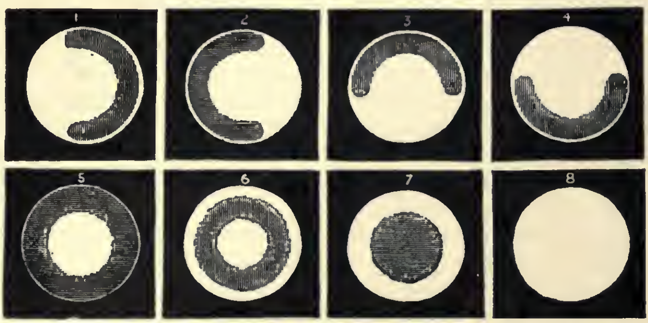


Fig. 47.—Showing the effects of having the lamp out of the optical center of the lense. In this figure the observer is supposed to be viewing the image thrown on the screen by the lamp.

CARE OF LENSES.

The condenser lens is the most troublesome item of the optical system since it is subjected directly to the intense heat of the lamp, especially with condensers having a short focal length, where the distance between the arc and glass is very short. Cracked condensers are the most common of the projector's ills.

Broken condensers may be caused by the close proximity of the arc, by forcing the arc above its normal capacity, by poor lamp adjustment in which the operator brings the lamp too close to the glass in making adjustments, by draughts of cold air in the lamp house, or by having the condensers fit too tightly into the casing. In the latter case the glass is broken through the expansion of the lens, causing it to crowd into the casing. There

should be at least 1-16 inch clearance space all around the lens.

Sudden changes of temperature are instrumental in breaking the lenses, and these may be occasioned by cold air currents entering through the ventilation holes of the lamp house, or by the rapid cooling of the lamp house after the lamp is extinguished. In several cases the loss of condenser glasses was reduced by covering the lamp house after the show, which had a tendency to relieve the internal strains of the glass through slow cooling. In my opinion this method is far superior to that followed by many people who attempt to anneal the glass by placing the lens in water and then bringing it slowly to a boil, as the temperature of boiling water is quite a bit below that necessary for the release of internal strains.

A dirty lens obstructs the light, even when the film of dirt is so slight as to be hardly noticeable to the naked eye. For this reason the external glasses of the objective lens and both lenses of the condenser should be cleaned thoroughly every day. The back condenser lens, which is inside of the lamp house, is especially fast to fog up, because of the fine dust or ash thrown from the carbon of the arc lamp. The back lens of the objective often has drops of oil thrown on it by the machanism of the motion head and should be watched carefully.

Loose dirt or dust may be removed by means of a soft camel's-hair brush, without taking the lenses from the tube, but the best method is to wash the outside lenses with a soft linen cloth moistened in alcohol. The alcohol should preferably be a half and half solution of alcohol and water, as pure alcohol drys too rapidly to enable perfect cleaning. Only old, soft cloth should be used, so that no scratches will be made on the surface of the lens, and to avoid deposits of lint.

Simply for the reason that a lens looks clean, when viewing it toward the light, is no sign that it is. Breathe on the surface of the glass, and if the cloud of moisture does not disappear almost instantly you can make up your mind that there are enough particles of dust present to hold the moisture. Occasionally, say once every month, the objective lens should be taken apart and thoroughly cleaned, both inside and out, with a cloth moistened in alcohol. Great care should be taken to get the

glasses back into their original and proper places or there will be unlimited trouble as the result. When cleaning the lens do not use too much alcohol, simply moisten the cloth.

With a cracked condenser it is possible to continue the show as long as the glass remains in the cell, without seriously injuring the projection. With lantern slides a crack in either glass will show on the screen, a crack in the front lens being more prominent than one in the rear. When the glass falls out of the cell, changes must be made in the system to save the show. If only one condenser glass fails, put the remaining glass in the front cell and move the lamp back until the apex of the light cone from this glass appears at the focal center of the objective lens. This will not affect the size of the picture, but will decrease its brilliancy.

A broken objective lens is almost a hopeless case as far as home repairs go, for it is difficult for the average operator to make the proper adjustments between the different lenses in the tube, even if it were possible for him to obtain a perfect mate for the broken lens. It is usually cheaper to obtain an entirely new lens.

After the proper lens has been obtained for the given picture size and throw, it may be tested for focus by inserting a strip of mica in the film window after a few scratches have been made on the surface of the mica. Care should be taken so that the mica occupies exactly the same position as the film would were it in place. If the scratch marks on the mica can be focussed on the screen sharp and clear and without any hazy or blurred spots the lens is accurate, and exactly in focus. This operation can be performed every day just before the show, so that no time will be lost in focussing after the film has started to run, thus sparing the audience the annoyance of focussing with the film.

SOURCE OF LIGHT.

Except for the equipment furnished for home projectors and for the outfits used by lecturers or traveling shows, electricity is almost universally used with the motion picture projector for the production of light, as it is possible to obtain nearly any desired degree of illumination. The electric light is by far the easiest high power

illuminant to control, is clean and safe. There are no tanks to fill or cause trouble, and the lighting energy supply is continuous without requiring attention on the part of the operator.

In the early days of the stereopticon, before the use of electricity was so widely adopted, the calcium light was the most common source of light in giving public exhibitions. The light in this form of lamp was produced by heating a small portion of a lime or calcium cylinder to incandescence by means of a jet of oxygen and hydrogen gas. The "lime light," as it was called, gave a very brilliant white light that gave very good results in projection as far as the picture was concerned, but unfortunately was unreliable and difficult to control. For good results it was necessary to turn the lime cylinder at very short intervals to prevent the flame from burning deep pits into the cylinder and to prevent it from cracking and falling off. The calcium was very brittle and likely to collapse entirely during the projection, causing serious interruptions in the performance.

Much trouble was also had with the breakage of the condenser lens, owing to the uncertainty of the flame control, in the case of pits in the cylinder that turned the flame back into the lens, or in the collapse of the cylinder. Two tanks were required, one for the hydrogen, and one for the oxygen, both gases being stored under high pressure. When illuminating gas was obtainable, it was used in place of the hydrogen, being much cheaper and easier to handle, but in both cases the oxygen tank was invariably used to increase the rate of combustion and increase the temperature, the atmospheric oxygen not being sufficient for this purpose.

Acetylene gas has been much used by traveling shows, but is not as brilliant as the electric or calcium light, and as the flame is much larger than the minute source of light of the arc or the incandescent point of the calcium candle, the projection results are not as good. In a general way the light is produced in much the same way as with the acetylene automobile lamp, except that a number of burners are used instead of the single burner used in the automobile.

The gas is taken either from an acetylene generator or from a storage tank in which the gas is stored under

a high pressure, in contact with a mass of wool saturated with acetone, a substance having a great affinity or absorbing power for acetylene. The method of generating the acetylene may be classified into two principal heads, those in which the calcium carbide is dropped into the water and those in which the water is dropped into a basket of carbide. In either case the gas is generated by the chemical reaction of water on the carbide, the latter being a dark, stony compound, greatly resembling dark dolomite or sandstone.

In all generators the generation of gas, or rather its pressure, is controlled by regulating the water supplied to the carbide chamber, the particular method adopted varying with each make of generator. Generally, the pressure of the gas is utilized in either raising the carbide from the water, or for forcing the water back and out of the carbide chamber when a certain predetermined pressure has been exceeded. Usually there is no provision made for storing the gas in any quantity, the gas being generated only as needed by the lamp. No oxygen tank is needed. Almost any automobile generator or gas tank may be used successfully with the acetylene projector.

Except with the smaller projectors, such as are used at home, the incandescent lamp is seldom used with the electric current. In the first place, the intensity of illumination is too low, and, secondly the illumination is spread over too great an area, making it impossible to obtain correct optical relations. The arc lamp in which the light is generated by a current passing through incandescent carbon vapor, in a space between two carbon electrodes, generates a most intense light per unit of area and therefore is very small and compact, the incandescent area being the nearest possible approach to the theoretical point required by the optical system.

THE ELECTRIC ARC.

When a conductor carrying an electric current is broken at any point in its length, the increased resistance of the air surrounding the gap causes a great increase in temperature; with sufficient current the temperature increase will fuse the material of which the circuit is composed and turn it into vapor. As the vapor in the gap, generally, is of a fair conducting value, much higher than

that of the air, the current continues to flow across the gap, vaporizing still more of the circuit material. This action will continue until the ends of the conductor are entirely consumed, or until the gap has been widened to such a point that the current can no longer overcome the increased resistance. The high temperature of the molten portions of the circuit cause a brilliant light, the intensity of which depends upon the strength of the current and the material of which the circuit terminals are composed. The higher the melting and vaporizing temperature of the material, the more intense will be the light, since the light evolved is proportional to the temperature.

In practice the terminals of the gap are always carbon pencils, as this material has a very high vaporizing temperature, is a fair electrical conductor, and does not form solid or liquid oxides or slag at high temperatures, as in the case of metallic electrodes. The carbons are of the same chemical composition as charcoal, the difference between the electric light carbons and charcoal lying principally in the physical form of the element, the electric carbon being pressed into a hard and solid mass, while the charcoal is porus and soft. The electric carbons are more nearly pure carbon than charcoal, being very nearly free from ash or other metallic oxides.

The character of the arc or flame between the two carbons depends primarily upon the nature of the current passing between the two points. The temperature and quantity of light depends on the rate at which the current flows across the gap, or the number of amperes as the rate of current flow is called. With direct current, or current that flows continuously in one direction, the greater part of the light issues from the "positive" carbon, or the carbon through which the current enters the gap between the ends of the carbon. At least 80 per cent of the light comes from the positive.

The source of light in the positive carbon is a little cup-shaped depression known as the "crater," which is maintained at a temperature exceeding 3,500 degrees Centigrade, the temperature at which the carbon vaporizes. The negative carbon is normally pointed at the end, and is also incandescent for a short distance from the end, but contributes little light, as it is at much lower

temperature than the positive. It should be remembered that the current is assumed to pass from the positive to the negative carbon across the gap. The vapor of the arc, which is of a violet color, contributes very little to the light, it being a thin and nearly transparent flame.

To obtain the greatest effect from the arc, the crater on the positive carbon should be pointed in the direction in which the light is desired. For this reason the upper carbon of a street arc lamp is always made the positive so that the crater will point down and throw the light on the street or sidewalk. In the projector, the crater faces the condenser lens as nearly as possible. Due to the vaporization of the carbon of which the electrodes are made, they gradually waste away, the positive

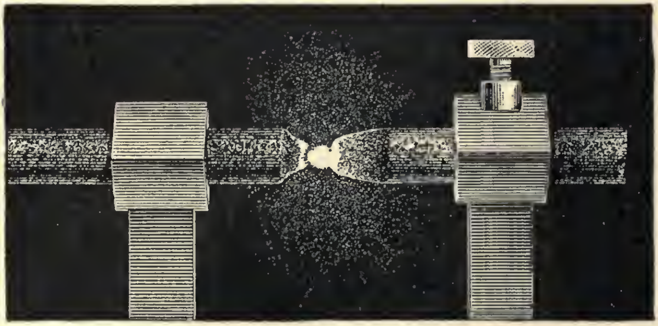


Fig. 47. Formation of the electric arc.

carbon being consumed at nearly double the rate of the negative. To maintain a uniform length of gap and a uniform amount of light it is therefore necessary to gradually push the carbons toward one another as the burning proceeds. To keep the arc in the same position in regard to a stationary point on the lantern, it is evident that the positive must be fed forward twice as fast as the negative. In street lamps the carbons are fed automatically by a mechanism contained within the lamp. With projector lamps all of the adjustments are made by hand, since not only must the correct distance between the carbons be maintained, but the position of the crater must be controlled as well, a task that is beyond the capabilities of any mechanism now made.

With alternating current, which changes its direction of flow periodically, there is no positive or negative carbon in a true sense, except for an instant before the reversal of the current takes place. The current in this case continually surges to and fro, making first one carbon positive and then the other. Both carbons in this case are consumed at an equal rate. Small craters are formed in both carbons with an alternating current, but neither of them is as hot or gives as much light as the single crater of the direct current arc. As the two craters are necessarily pointed in opposite directions it is possible to utilize only a small portion of the light given by either of them, the total amount of light being very small when compared with the direct current light with an equal amount of current.

The carbons of a direct current arc lamp are set

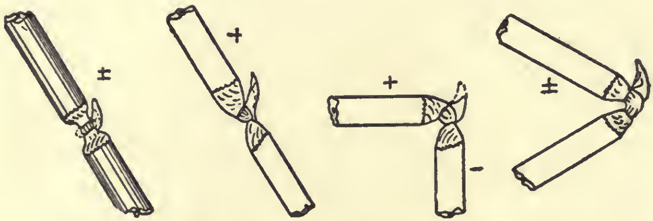


Fig. 48. Differing arrangements of carbons.

at an angle of from twenty to thirty degrees with the optical center of the projector, with the arc directly on the center line, so that the crater partially faces the condenser. By offsetting the carbons, or by pulling one carbon past the center line of the other, about one-eighth of an inch, the upper, or positive carbon, burns diagonally, so that the crater slants still more in the direction of the condenser, giving more light at that point. The exact angle at which the carbons are inclined to the center line of the lens depends upon the length of the arc and the amount of offset, as with a long arc it is possible to incline the carbons farther and bring the crater more nearly into the field of the condenser without danger of having the lower carbon coming between the crater and the lens and interfering with the light. The lower carbon of course would throw a shadow on

the condenser. The carbons are parallel with one another.

With alternating current, the carbons are set at an obtuse angle with one another, for, if they were parallel, the light would be thrown equally in all directions. When set at this angle the light is thrown out from the apex of the angle which coincides with the location of the arc.

REDUCING AND RECTIFYING THE CURRENT.

Since the voltage across the arc is only 45 volts, with a lighting supply ranging from 110 to 220 volts, it is necessary to reduce or "choke down" the excessive flow of current that would result from this great difference in

Fig. 49. Arc regulating mechanism in projector.

voltage. An electric arc has no definite resistance, like other apparatus, due to the fluctuations in the length of the gap between the carbon points, so it is evident that the device inserted for the reduction of the flow must be variable in capacity to meet the different conditions that occur in feeding the carbons.

There are various methods of controlling the current flow, the exact method depending on the character of the current (whether direct or alternating), and the permissible cost of the apparatus. The simplest device is a "resistance" placed in series with the arc, which is commonly known as a "rheostat," the action of this being similar to a mechanical brake or friction clutch on a machine that is used for stopping or reducing its ve-

locity. In both cases the excess energy is converted into heat, which is dissipated into the surrounding air.

A rheostat is a most uneconomical method of reducing the current, as a very great proportion of the current passing through the meter to the arc is converted into useless heat. On a 110 volt circuit this heat production represents approximately 53 per cent of the total energy, while on 220 volts nearly 78 per cent is thrown into the air. The rheostat is an absolute necessity with direct current, this being practically the only objection to this class of supply, while its use with alternating current is optional. When the rheostat is used in series with the arc, at least 15 volts should be allowed above the 45 volts required by the arc, making the equivalent arc voltage 45+15=60. Sixty volts should be the minimum pressure for the arc circuit.

To find the resistance necessary for a given line voltage we apply Ohm's law, a formula in which E represents the voltage of the line; C is the required current in amperes; and R is the total resistance of the circuit in ohms. According to the formula.

$$R = \frac{E}{C}$$

The value of E in the case of the arc circuit is obtained by subtracting the voltage of the arc (45 volts) from the total line voltage before proceeding with the rest of the calculation. If the voltage is 220, and the arc voltage 45, E would be, 220—45=175 volts. Substituting this value of E in the formula, we have

$$R = \frac{E}{C} = \frac{(220-45)}{25} = \frac{175}{25} = 7$$ ohms, the required resistance of the rheostat. Rheostats are manufactured for different voltages and current capacities and for this reason it is essential to specify the maximum current and voltage used.

The actual rheostat consists of an iron case in which is mounted a number of coils of resistance wire, the coils being mounted on incombustible insulating spools which insulate the wire from the case. These coils are connected in "series," that is, the end wire of one coil is connected to the beginning of the second, and so

on through the series, making it necessary for the current to flow through the entire length of all of the coils in turn. In effect this is the same as a single resistance wire equal in length to the sum of the individual coils. The wire used in the rheostat coils has many times the resisting value of the copper wire commonly used in making the connections, so that the rheostat will be as small and compact as possible. With a given quality and size of wire, the resistance depends entirely upon the total length of the wire. The longer the wire, the higher the resistance. The current carrying capacity depends on the diameter of the wire, and not upon its length.

The majority of rheostats are of the adjustable type, in which it is possible to cut out more or less of the coils, thus varying the resistance. Cutting out the coils reduces the resistance and increases the current. This operation may be performed by means of a switch lever, or by changing the connections of the lamp in regard to the coils. In the latter type of rheostat, one line wire is connected to the end of the last coil, while the other line wire is connected to points between the remainder of the coils, this intermediate connection preventing the current from flowing through a number of the coils.

When it is found necessary to increase the current capacity of the rheostat, a second rheostat may be connected in "parallel" with the first, that is, the two wires of the second rheostat are connected with the end wires of the first, so that the current is split up into two different paths, one-half of the current going through one rheostat, and one-half through the other. Since the same voltage acts on both rheostats, the same amount of current passes through each one of them, as in the first case, making the total current double that of the single rheostat. This is the same thing as doubling the flow of water into a tank by supplying two pipes instead of one. If more than double the capacity of two rheostats is required, the levers or connections of both the rheostats may be changed, as in the case of the single rheostat, taking care, however, to make the same change on both rheostats.

In this connection it should be understood that both rheostats should have the same amount of resistance to

prevent an excessive current from flowing through the rheostat having the lowest resistance. If the separate "steps" of the rheostats are not of the same resistance, there will be a greater current through one than through the other, when the intermediate connections are made.

When heavy currents are used, cast metal "grids" are used in place of wire coils, as it is usually more convenient to obtain a compact resistance with the castings than with the large diameter wire that would be necessary under these conditions. The "grids" of this type are thin plates, slotted from either side, so that a zig-zag circuit is formed from one end of the plate to the other.

The rheostats used for alternating current are identical in form and principle to those used with direct current.

Should the coils or grids of the rheostat become red hot with the full resistance in circuit, it is evident that the resistance is too low for the work, or that the rheostat is too small in regard to current carrying capacity. If the arc is right under these conditions and not drawing excessive current for the projection required, a rheostat of higher capacity should be obtained at once, to avoid the necessity of a shut down, due to burned out coils. The coils should be invisible in the dark, even when working at their fullest capacity. The best resistance wire made deteriorates at red heat.

EMERGENCY RHEOSTAT.

In case of an emergency due to the failure of the rheostat, a simple resistance may be made out of a pail of water and two metal plates. The pail is nearly filled with pure water and the plates are then immersed after being connected with the two wires leading from the main supply circuit and lamp. As pure water is practically a non-conductor, salt or sal-soda is now added to the water at intervals, and in small quantities, in order to increase the conductivity of the water. The addition of the salt is continued until the required amount of current is flowing through the lamp.

Use only a wooden pail for a water rheostat, as the plates are to be hung over its edges, and stand the pail on a chair or other insulating support to avoid a ground. The metal plates are connected in circuit

in the same way as the usual rheostat, one plate being connected with the lamp, the other with the supply circuit. For high voltages, such as the 550 volt current used on street railway systems, a number of pails can be connected in series, or a larger rheostat may be made with a barrel.

With the pails, it will be found possible to run through an entire evening with a current as high as 40 or 50 amperes; it usually being necessary to add a little water from time to time to compensate for the loss by evaporation and electrolysis.

ALTERNATING CURRENT REGULATION.

In general, there are five methods of reducing the voltage of the line to that of the lamp:

(1) Rheostatic resistance.
(2) Reactance coils.
(3) Transformers.
(4) Mercury arc converters.
(5) Motor generators.

The device used depends principally on whether alternating current is to be used at the arc, or whether the alternating current of the line is to be converted into direct current in addition. The first three appliances listed simply reduce the voltage at the arc, without changing the character of the current. The mercury arc converter and the motor generator transform the alternating current into direct.

As explained under the head of "the arc light," it is far preferable to have direct current, because of its greater efficiency and the greater purity of color in the projector. Unfortunately, all of the converting apparatus is expensive in the first cost, and in one case, expensive in its maintenance. The rheostat mentioned is exactly the same as the one previously described, the three succeeding devices cannot be used with direct current. The fifth item—the motor generator—may be used on both alternating and direct current.

TRANSFORMERS

Transformers reduce the line voltage of alternating currents without introducing ohmic resistance into the circuit, by a principle known as "induction." Two separate systems of copper coils or circuits are provided that are absolutely independent of one another, and which

have no electrical connection, the line current passing through one coil, and the lamp current through the other. Both coils are wound over a single iron core, and are insulated from the core as well as from each other.

As the line current surges through the coil (*primary coil*), it alternately magnetizes and demagnatizes the iron core around which it is wrapped. As the lamp circuit coil is wrapped around the same core, the magnetic influence also passes through the turns of wire that constitute this coil, generating a current in the lamp circuit. By properly proportioning the dimensions of the core, and the number of turns in the two coils it is possible to obtain any desired relation between the voltage of the primary coil (main circuit coil) and the secondary coil (the lamp circuit coil).

The efficiency of the transformer is the highest of any piece of commercial electrical apparatus, and therefore the transformation in voltage is accompanied with very little loss in energy. This loss is seldom more than 10 per cent in a well designed transformer and is usually 5 per cent or even less. The current "induced" in the lamp circuit is of course alternating, as it follows the impulses of the line current in the primary. The secondary coil is connected to the lamp circuit in the same way that the direct current supply wires leading from the rheostat and line are connected to the lamp. The primary coil is connected directly across the line through a suitable switch and fuse.

The core and coils are placed in an iron box which is then filled with insulating oil, that increases the insulation and aids in getting rid of the small amount of heat that is generated in the coils. Taps are often led from intermediate points in the winding so that the voltage may be raised in the primary circuit.

REACTANCE COILS (CHOKE COILS)

A *reactance* or *choke coil* consists of a single coil of copper wire wound around an iron core, this coil being placed in series with the lamp and supply circuit. In effect, it is a combined primary and secondary, as the line current in passing through the coil, magnetizes the core, which in turn generates another current that is

opposed in direction to the line current. The individual current created by the core of course cuts down the current flow by creating a pressure in the opposite direction, the exact quantity of current depends on the "reactance" or upon the number of turns and the properties of the core.

In the case of the reactance coil, the line current passes through the lamp and is alternating at all points in the circuit. The efficiency, while not as high as in the case of the transformer, is much higher than with a rheostat, and very little energy is dissipated in the form of heat. The current can either be regulated by means of intermediate tapping points on the primary or by sliding the iron core in relation to the coils.

MOTOR GENERATORS

When alternating current is to be converted into direct by means of a motor-generator, the set consists of an alternating current motor and a direct current dynamo connected by a coupling on the ends of these respective shafts. The energy taken from the a. c. mains by the motor drives the dynamo, which in turn generates direct current at the proper voltage for the lamps. This transformation is accompanied by an efficiency loss of from 20 to 40 per cent, due to the bearing friction and electrical losses in the two machines. This loss is more than offset by the increased efficiency of the lamp, when using direct in place of alternating current, and in the increased brilliancy of the projection.

MERCURY VAPOR RECTIFIERS

When an alternating current is led into an exhausted glass vessel containing a small puddle of mercury so that the puddle forms one electrode, it will be found after establishing the current flow in one direction, that the current will instantly cease at the moment of reversal. In this way, the simple mercury tube will allow waves to pass in one direction, but not in the other, the reverse waves being dammed out by an increased ohmic resistance that is built up at the instant of reversal. By means of small reactance coils in addition to the tube, it is possible to obtain a nearly continuous flow of direct current with an alternating supply. During the operation of the tube, the current passes

through the vapor formed by the heated mercury causing a faint bluish green light.

After continued service, the internal conditions of the tube become altered and finally the tube becomes useless so that it must be replaced by an entirely new tube. These replacements are expensive and add a very considerable amount to the running expenses of the show. The life of a tube is about 600 hours.

CARBONS AND THEIR CARE.

As explained in a preceding paragraph, the carbons are composed of some form of solid carbon such as coke, retort residue, or soot, the carbon particles being held together in a suitable form by means of a "binder." After being very carefully pulverized, the carbon dust is mixed thoroughly with the semi-fluid binder, is drawn into a cylindrical form through dies, and then is baked into a hard homogeneous mass. The baking process reduces the binder into carboniferous mass similar to the original carbon base so that the cross-section of a solid carbon is of practically a uniform consistency. In drawing "cored" carbons, a small hole is left in the center of the rod for the reception of the semi-porous core that is squirted into place after the baking. This core is generally made of carbon dust with a water-glass binder which is dried in place, and not baked as in the case of the outer hard carbon shell.

The core aids in keeping the crater of the arc in the center of the carbon, because of its relatively lower resistance, and is an absolute necessity with alternating current. For direct current, the upper carbon is cored and the lower is solid, the upper carbon being the positive. With alternating current both carbons should be cored as the crater is formed on both.

The quality of the carbons, as well as their correct adjustment in the lamp is of the greatest importance in obtaining satisfactory projection, and the inferior brands or seconds should not be tolerated in even the smallest shows. Cracks, sputtering, off colored light, and a hundred other troubles can be traced directly to the use of cheap commercial rods intended for general illuminating purposes.

The size of the carbons depends principally upon the amount of current used, and also to some extent upon the machine, the character of the current and the make of the carbons. This point is best determined by experiment, the operator trying out different makes and sizes from time to time until the best combination is found. Two sizes of carbons are generally used with direct current, the upper carbon being from 1/16 to ⅛ inch larger in diameter than the lower. With alternating current both the upper and lower are of the same diameter. The following tables will serve as a guide in selecting the proper diameter when the current consumption is known.

CARBONS FOR CONTINUOUS CURRENT.

Current	Solid Lower Carbon		Cored Upper Carbon	
Amperes	Inches	M. M.	Inches	M. M.
10-15	.394	10	.511	13
15-25	.472	12	.630	16
25-40	.511	13	.709	18
40-50	.551	14	.787	20
50-60	.630	16	.866	22
60-100	.709	18	.984	25

CARBONS FOR ALTERNATING CURRENT.

Current	Upper and Lower Cored Carbons	
Amperes	Inches	M. M.
15-25	.394	10
25-35	.511	13
30-40	.630	16
40-50	.709	18
50-65	.787	20
65-80	.866	22
80-100	.984	25

In regard to the length of the carbons, it is certainly advisable to obtain the longest rods that can be conveniently used in the lamp house, for owing to waste ends, or "butts," the percentage of waste is less with the longer rods since the butt is of the same length in all cases. In this way, a large lamp house is an important factor in cutting down the carbon bill and in the loss of time due to the renewals of the carbons. The carbons should be perfectly straight and round, and of a uniform diameter so that it will not be necessary to continually readjust the lamp during its operation.

When setting up a projector that is to be used with direct current, be sure that the upper carbon is connected

with the positive pole or wire of the supply main. The polarity can be determined by temporarily connecting the lamp with the mains, installing the carbons and turning on the current. After burning for two minutes or so, open the switch and examine the carbon points. The carbon that remains red hot the longest is the positive. If the hottest carbon is not in the upper holder, reverse the wires before attempting to operate the machine. It is only necessary to make this test once, as the illuminating companies exercise great care in maintaining a constant polarity on their mains. When performing this test, it is almost needless to say the rheostat should be placed in series with the lamp before closing the switch, and that the carbons should be of equal sizes in both holders.

After burning, it will be noted that one carbon, the positive, has a small depression that indicates the position of the crater. The presence of the crater is not as accurate an indication of the polarity as the test previously given, especially if the lamp is only burned a few minutes, as is usually the case under test conditions.

In adjusting the carbons, it should be borne in mind that the object of the operation is to have the crater face the condenser lens at as flat an angle as possible, and to have its area as great as possible with a given current. The amount of light that is thrown directly on the condenser lens determines the efficiency of the lamp, for very little light is reflected from the sides of the lamp house to the lens.

All modern projectors are provided with hinged lamps that allow of a considerable variation in the angle that the lamp makes with the center line of the lenses, so that the location of the crater is easily brought to the correct point in regard to the condenser. Practically the only limit to the angular position of the crater is that imposed by the lower carbon. With too great an angle the lower carbon tip will come between the crater and condenser and cause a shadow.

The position of the crater on the carbon tip may be brought to the front by advancing the lower carbon. If the carbons are directly in line with one another the crater will be too low resulting in the greater part of the light being thrown to the bottom of the lamp house. This back and forth adjustment of the lower carbon is gen-

erally made by means of a hand wheel that extends through the back of the lamp house.

Both carbon tips should be sharpened to a flattened cone form before inserting in the holder, the flattened end space being about one-quarter of an inch in diameter. This point will be your guide in setting the carbons after striking the arc and is instrumental in sustaining the arc until a permanent crater is formed. Since the resistance between the carbon and carbon clamps is directly proportional to the pressure exerted by the clamps on the carbons they should be carefully tightened before turning on the current in order to prevent excessive heating at the points of contact. With poor contact, minute portions of the carbon will be consumed under the clamp which will result in an additional resistance and heating effect due to small arcs that will be maintained between the clamps and the surfaces of the carbons.

With excessive currents, or poor contacts, the binding material of the rods will be consumed resulting in deposits of carbon dust in the lamp house on the carbon holders. With the contact pressure and current remaining constant this effect is, in a way, an index to the quality of the carbons, some of which have a higher internal resistance than others. This loss of materials is particularly noticeable in the vicinity of the arc where the carbons will taper to a long needle point. Solid deposits are sometimes carried across the gap from the upper to the lower carbon causing a heavy mushroom tip on the lower carbon. This is generally caused by an extremely short arc across which the carbon gas passes without becoming completely oxydized. This carbon gas on coming into contact with the comparatively cool negative carbon is condensed forming the "growth" before mentioned. The only remedy for this condition is a longer arc.

The inside of the carbon clamps should be smoothed up every few days with a file or emery cloth as the oxide scale and rough metallic surfaces cause very bad contact. The increased heat due to a dirty clamp is instrumental in weakening the carbon clamps and arms which are generally of bronze, a metal that weakens

rapidly at a comparatively low temperature. If the clamps are causing much trouble it will be best to have a new set made up of steel bar by the local blacksmith.

With direct current, the lower carbon should be advanced only enough to bring the crater to the front edge of the upper carbon, and no more. If the advance is excessive, the crater will extend up and along the front face of the upper carbon with the result that only the front half will be consumed, leaving a long unconsumed strip in the rear. If the advance is not sufficient the crater will be too low and will not face the condensers.

When alternating current is used, the adjustment is much more particular as the craters are much smaller and much more easily affected by a slight change in the movement. Both carbons should incline at a considerable angle with one another (forming an obtuse angle) and the ends of both should face the condenser at the same degree, since with alternating current, a crater is formed in both carbons. Compared with direct current practice, the alternating arc is comparatively short.

WIRING REGULATORS.

In nearly every town, the installation of electric light wiring is regulated by ordinance, the exact requirements of which vary with the locality. In every case, the wiring is regulated by the board of fire insurance underwriters whose authority is fully of as much importance, at least financially, as that of the city government. No exhibitor should attempt the wiring of his house until he, or his architects, are fully informed as to the regulations of both of these bodies. In the larger cities, the illuminating companies usually refuse to connect the interior wiring to their service until the exhibitor produces an inspector's certificate showing that the wiring has been approved. Because of the wide variation in these demands it is only possible for us to give instructions that apply to all installations, regardless of the locations of the proposed house. Details as to wire sizes, insulation, materials, etc., will have to be ascertained individually by the authorities in charge.

THE CIRCUIT (DIRECT CURRENT).

A complete path around which an electric current

flows is known as its "circuit." In the case of the projector circuit, this path is made up of the lamp, the rheostat (or other current-controlling device), the meter, fuses and switch. With the switches closed and all parts in their proper relation so that it is possible for the current to flow the circuit is said to be "closed." When the switch is opened, or the path broken, the circuit is said to be "open."

Starting at the pole line of the illuminating company, the direct current supply leaves the positive wire, enters the building, passes through the meter, the switch and fuses, passes through the rheostat, through the lamp, and back to the negative wire of the pole line. When the switch or fuses open the circuit is opened, and the current ceases to circulate. On its return, the current passes through a second blade of the switch, so that when the switch is pulled, the circuit is opened on both the positive and negative wires. A switch that opens both the positive and negative lines is known as a "double pole" switch, and is an absolute necessity if the circuit is to be entirely disconnected from the supply as is usually the case. The one exception is in the case where current is taken from a street railway circuit where only a single pole switch is used.

The *meter* registers the amount of electrical energy taken from the supply mains and is invariably the property of the illuminating company. It registers the current in terms of "kilo-watt hours," this unit being the product of the voltage by the current in amperes. This is then further multiplied by the number of hours through which the current has been acting. The total product is then divided by 1,000. Stated as a formula this will be—

$$\text{Kilo-watt hours (KWH.)} = \frac{V \text{x} A \text{x} H}{1{,}000}$$

where V = volts. A = amperes, and H = no. hours.

The *fuses,* which are simply strips of some easily fused metal mounted in a suitable container, form a guard against excessive currents that may be drawn through an accident to the lamp, rheostat, or wiring. As the fuses have a much lower melting temperature, and

have a smaller diameter than the copper wiring, a heavy current will "blow" them out before it has had an opportunity to damage the rest of the circuit. In other words, the fuses are simply a protective device installed for the purpose of saving the most expensive parts of the circuit, the fuse being a form of automatic switch. The balance of the circuit has been already described. After the fuses have been blown, and the trouble located, they may be easily and cheaply replaced by others.

WIRING THE BOOTH.

All wire used in the interior of the building is covered with a non-conducting substance such as rubber, or a saturated braid composed of fabric and a compound such as kente or mineral wax. This covering is known as insulation, and is for the purpose of confining the current to the copper wire that it protects. If bare wire were used without insulation between the positive and negative wires, a "short circuit" would be formed, that is, the current would pass directly from one wire to the other without doing useful work in the lamp house, providing, of course, that the resistance between the wires was lower than that of the lamp.

Defective insulation is one of the most common of electrical troubles, and is a continual source of danger and expense until it is repaired. Leakage of the current, however slight, increases the chances of fire, and is a continual expense through turning the meter during the idle periods. Besides it is a cause of annoyance to the operator because of shocks that he obtains when operating the machine or in making connections.

Nearly all authorities require an insulation that is waterproof and which burns slowly and without flame when ignited by a short circuit or otherwise. Protection against moisture is usually provided by a layer of rubber, while the protection against mechanical injury and fire is provided by an outer braid saturated with some fairly incombustible compound. A cotton covered or paraffined wire should never be used on a lighting circuit.

In general, there are two methods of supporting house wiring, the first consisting of porcelain cleats or spools that raise the wires from the surface of the

wall on which they are run; the second (and by far the best) consisting of iron pipes through which are passed both wires of the circuit. The second method is used in nearly all large cities where the regulations are severe. In any case, the wire should never come into contact with walls, ceilings, wood-work, or metal parts that are connected with the ground, even if the wires are perfectly protected with an insulating cover. Disregard of this precaution is apt to result in a fire.

When metal tubing, or "conduit" is used on alternating circuits, both the positive and negative wires should be run through the same tube to prevent troubles from induction. When porcelain insulators are used in "open wiring" particular care should be taken to have the wires taut and straight so that they cannot sag and come into contact with the wall or with one another. Where open or porcelain cleated wires pass through a wall, they should be protected by a porcelain tube that runs through the entire thickness of the wall.

The size of wire used on any circuit depends on the number of amperes to be carried and upon the length of the line, and also to a certain extent upon the nature of the insulation. The voltage has no direct bearing on the cross-sectional area, when the current is known. With equal lengths, the capacity of wire varies directly with the cross-sectional area or with the square of the diameter. Thus a wire of twice the diameter of another has four times the capacity as will be seen from the following example in which one wire has a diameter of ½-inch and the other a diameter of ¼-inch—

$(1/4'')^2 : (1/2'')^2$ :: capacity 1 : capacity 2, or
$1/16 : 1/4$ :: capacity 1 : capacity 2.

In practice, the length of the circuit is of as much importance as the diameter of the wire, since a long wire has more resistance, and therefore reduces the voltage at the far end of the line with an equal current. To overcome the effect on the voltage a long wire must be larger in diameter than a short one with an equal current in amperes.

The exact calculation for current and length should

be performed by an electrician as the process and explanations that are connected with it would occupy too much space in this volume. The minimum size of wire permitted under any conditions is a No. 14 Brown and Sharpe gauge, even though this wire would figure larger than necessary for the current.

As a guide in selecting *short wires,* (not exceeding 15 feet in length) we will add the following table supplied by the National Board of Fire Underwriters.

B. & S. gauge.	Amperes for Rubber Covered Wire.	Amperes for Weather-Proof Wire.
No. 14	12	16
No. 12	17	23
No. 10	24	32
No. 8	33	40
No. 6	46	65
No. 4	65	92
No. 2	90	131
No. 1	107	156

It will be noted that the current carrying capacity of rubber-covered wire is much less than a weather-proof wire of the same size. This is due to the fact that rubber deteriorates more rapidly than the weather-proof compound with equal degrees of heat caused by the passage of the current. Since the heat generated is in direct proportion to the amperes flowing, the rubber table is reduced in proportion to the current. Only rubber-covered wire should be used in the interior of the theater, the weather-proof being allowed only on open, out-of-door lines.

When two lengths of wire are to be spliced, the insulation should be completely removed from the ends of both wires for a distance of from 2 to 3 inches. The base ends should now be thoroughly scraped until the metal is bright and shining and with no trace of dirt or compound. Care should be taken not to cut or nick the wire in any way during this process. The base ends should now be tightly wound around one another in a close neat spiral so that the wires bear on one another in close contact throughout their length. The joint should now be heated in the flame of a gasoline torch and a stick of solder rubbed back and forth until the wires are completely united. Never make a joint without soldering it thoroughly for a simply wrapped joint will oxydize, heat and eventually burn off. After soldering, wrap the joint with several layers of electrical

tape, starting and completing the wrapping over the rubber insulation on either side of the base conductor. The tape should overlap the rubber by at least an inch on either side.

In making any connection it should be remembered that the contact surfaces must be perfectly bright and clean. The smallest particle of dirt between the two surfaces decreases the area of contact and correspondingly increases the resistance and heat. Loose connections have the same effect. Keep all binding screws as tight as possible, and make a practice of going over these joints at regular intervals.

THE FILM.

Owing to the difference in the mechanical details of the many machines now on the market it is almost an impossibility to give an exact description of the methods adopted in threading the film through the motion head that will apply to every machine. In nearly every case, however, the film is wound on the upper reel (before exhibiting) by first inserting the end of the film under the spring clip on the core of the reel, and then rotating the reel by means of the projector mechanism or by a separate winding device called a "rewinder." In some cities the use of a separate rewinder is made necessary by an ordinance which sometimes requires this operation to be carried out in a separate room, or in any event, outside of the operating booth. The emulsion side of the film should be "in," that is, should be faced towards the interior of the reel.

When the reel is filled, it is placed in the upper magazine, and the free end of the film is brought out through a slot in the bottom of the magazine. It is now brought out over an idler, under the top sprocket, and from there is placed in the film gate, after leaving a loop of slack film above the gate. The top sprocket which is driven by the crank, pulls steadily on the film and unwinds it from the upper feed reel. The loose loop prevents the intermittent feed from jerking the film against the inertia and friction of the reel and breaking it off above the gate. When the gate is closed, the film is between the film gate and the framing plate, a spring-actuated device in the gate holding the film

against the framing plate in front of the aperture. The friction caused by the springs checks the momentum of the film so that it comes to rest instantly opposite the aperture. The springs rest on the blank margin of the film and the entire device is arranged so that nothing comes into contact with the film in the picture space, thus avoiding the danger of scratches. Owing to the inversion of the lens, the film pictures should be placed so that they are upside down in the aperture, with the emulsion side towards the light.

A second loop is now formed at the bottom of the gate, between the gate and the lower take-up sprocket. A spring-controlled idler pulley holds the film firmly on the lower sprocket. After passing over another idler, the film is led to the lower "take-up reel," where it is fastened to the core of the reel by means of a spring clip similar to that on the feed reel. The machine is now ready to be run.

As no attempt has been made to place the film pictures in correct relation to the aperture or feeding mechanism, it will be found necessary to secure this adjustment by means of the "framing device" which brings the picture "into frame" or into the correct position on the screen during the time that the shutter is open. Framing is accomplished in different ways on different machines, but is usually accomplished by raising or lowering a lever on the motion head, that raises or lowers the aperture plate.

When threading the machine, the greatest of care should be exercised in order to prevent injury to the delicate emulsion surface. Even the smallest abrasions or scratches are glaringly apparent on the screen because of the great magnification. The rapid succession of small scratches and dirt specks, no two of which fall in the same place on the screen, produce what is known as "rain," an expression that describes the appearance of such a film very clearly.

Holding the film between the fingers when rewinding, or tightening the film on the reel by pulling at the end of the film with the reel held stationary are the two methods that most commonly result in rainy films. Carbon dust or dust from the interior of the lamp house are also common causes of rain, since the fine particles

embed themselves in the soft emulsion. Nothing should touch the emulsion surface, especially while passing through the machine or in rewinding. "First-run" film is soft and is especially susceptible to friction and dirt.

The friction of the tension springs in the gate and the rubbing of the guide rollers and sprocket wheels on the margin of the film removes a considerable amount of emulsion especially with first run films. This emulsion dust causes much trouble and should be removed at short intervals to prevent film scratches and mechanical troubles that often arise when the deposit is allowed to accumulate. Deposits that form under the tension springs should be removed after each run to prevent spring-jumping and slippage.

DRY FILM.

Before leaving the developing rooms of the film producer, the emulsion is charged with a small amount of emulsion soft and pliable. After a time in service, the glycerine which keeps the gelatine component of the glycerine finally evaporates and the film again becomes harsh and brittle. The evaporation of the glycerine is, of course, hastened by heat, and for this reason the film should never be stored in a warm place, especially near the ceiling of the operating booth. A considerable amount of moisture should be supplied to keep the film in its best condition. At the present time there are special sheet-metal film containers on the market that are built on the principles of the well-known "humidors" used for the storage of cigars. These devices are circular metal cans, just large enough to receive a reel of film, and are provided with a perforated metal bottom that covers a sponge or other absorbent material. A small amount of water in the sponge supplies the necessary moisture to the film without danger of wetting the emulsion.

When the film is dry it may be moistened by unwinding it into a large can, such as a milk or garbage can, that is provided with a false bottom of wire screening. The wire screen is raised two or three inches from the bottom of the can, or high enough to accommodate a shallow pan of water that is to be placed beneath the screen. The cover is now placed on the can, and the film

is left in the moisture for a period of an hour to half a day, depending on the condition of the film. If the film is left on the reel, it will require a considerable length of time for the moisture to penetrate to the center of the reel. In any case do not allow the film to become too moist.

The manufacturers and film exchanges often "rebathe" the film in a three per cent solution of glycerine in water. This process, however, is usually beyond the capabilities of the exhibitor or private film owner, as handling a thousand feet of wet film is no easy matter unless one is equipped with the proper devices. The manufacturer winds the film on large squirrel cage drums and then rotates the film through a glycerine bath contained in a shallow tray. The tray is then removed, and the cage rapidly rotated until the film is perfectly dry.

Great care should be taken in handling a wet film for the emulsion is very soft, about the consistency of jelly, and is easily damaged by even the slightest contact. Dust adheres firmly to the wet collodion, and when once imbedded is almost impossible to remove.

Should a film be wet accidentally, it should be immediately unrolled, and either stretched or wrapped around some cylindrical object such as a barrel or patent clothes-reel. In any case the emulsion side should be turned outwardly so that it will not come into contact with the surface on which it is wound. The unrolling should be performed very carefully to prevent injury to the emulsion. Do not release the tension until the film is bone dry to prevent it from curling and winding.

LEADERS.

A piece of blank film, or title, of from two to four feet in lenghth, is attached to the beginning of a film to allow for threading the machine. This is known as the "leader." The length of the leader should be greater than the distance from the feed reel to the take-up reel so that the crank may be turned through a couple of revolutions before the body of the film enters the gate. If the leader is too short, there will be equivalent loss of title in threading, making it almost impossible for the audience to determine the name of the play. In attaching a new leader to a film care should be taken to have it in frame with the rest of the film.

As the leader is not projected on the screen it can be made from any old piece of film that is in good condition in regard to the sprocket holes.

A "tail piece," similar to the leader should be attached to the end of the film, and should be at least long enough to reach from the feed to the take-up reel so that the body of the film will be on the take-up before the tail piece ends on the feed reel.

PATCHING THE FILM.

A properly made patch or mend is of the greatest importance, for the continual parting and jumping caused by imperfect work is a source of annoyance to the audience and a cause of loss to the exhibitor. Properly made, a patch is nearly as strong as the film on which it is placed, and will run nearly as true.

The first requirement is that the sprocket holes between the two ends of the film shall be spaced at the exact standard distance, so that the patch will pass over the sprockets without jumping. The edges of the two halves of the film must coincide exactly, and must be in the same straight line so that the film will run true through the gate and wind evenly on the reel. The cemented surfaces must be perfectly clean and in full contact with one another, a condition that depends on thorough scraping and heavy clamp pressure.

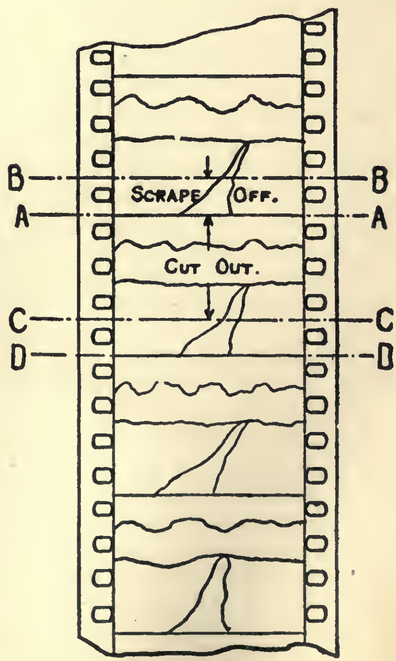


Fig. 50. Proper Way to Splice.

Mending the film is a very simple operation, but it

is usually done so hurriedly that the patch opens up sooner than if it was done right. The operator should have a pair of small scissors to cut the film, a sharp knife to scrape off the emulsion, and good film cement. Most

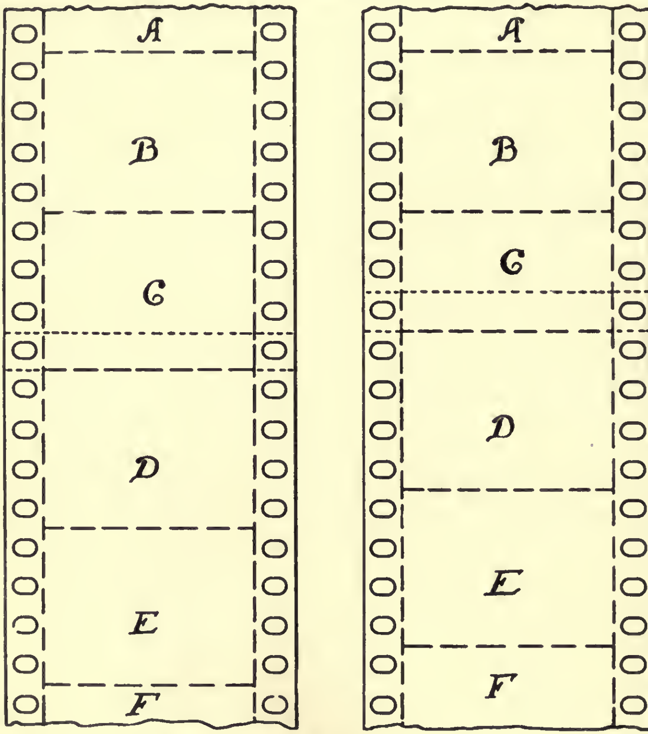


Fig. 51. Showing Proper (Left) and Improper (Right) Film Splices.

film cement is put up in bottles having a small brush fitted into the cork. In this way the bottle is always kept tightly corked and the brush for applying the cement is always at hand and in condition to use.

To patch the film so that no frame-up will be necessary when it passes through the machine cut off one picture on dividing line *A-A,* and the picture below at *C-C* one sprocket hole above the dividing line (Fig. 51). Moisten flap *A-A, B-B,* with water and scrape the emulsion off with the knife blade. Be sure to get it all off as

the cement will not stick to the old emulsion. Now scrape off back of *C-C, D-D,* to remove the grease or dirt on it. Apply the film cement liberally on flap *A-A, B-B,* where it has been scraped, and lay part *C-C, D-D* on top, being careful to see that the sprocket holes come directly over each other. The best way is to match the holes on one side, holding it with the thumb and one finger; then match the other sprocket holes and press the whole joint together and rub firmly with the thumb and finger. All this must be done very quickly as the cement dries rapidly, and when once dry, and the film does not stick, it must be scraped off again and tried over. If a larger flap than one sprocket hole is used the film at the patch becomes too stiff and in going over the round sprockets the patch will open up. After completing the patch cement the edges down by running the brush over them, as that is always the first part of the patch to open up.

JUMPING AND SWAYING FILM.

A very slight difference in the position of the successive pictures in regard to the aperture and the shutter makes a very considerable difference in their position on the screen owing to the magnification of the lens. Since the film picture is often magnified 240 times it is evident that a difference of 1/100 of an inch in the position of the pictures amounts to 240/100 = 2.40 inch on the screen, a displacement that is very apparent to the audience, and one that is very annoying.

Pictures that are out of register may be caused by any or all of the following defects in the film:

(1) Worn sprocket holes.
(2) Dry film, whose shrinkage has caused the sprocket holes to come too close together or run out of alignment.
(3) Poorly made patches.
(4) Curled film.

In addition to the film defects, jumping and swaying may be caused by defects in the projector mechanism, such as worn sprocket teeth, loose shutter, loose lens, glasses or tube, worn intermittent movement, or to the machine rocking on the floor while being cranked. Deposits of emulsion dust under the tension springs will

also cause jumping. The lens and its mounting should be examined occasionally and tightened.

THE MOTION HEAD.

Because of the great difference in the construction of the various motion heads now on the market, I will attempt only the most general of hints in regard to their care. To describe all of the makes, as well as the num-

Fig. 52. Examining Film to see if properly spliced.

ber of types that have been produced from time to time by each maker would require far more space than I have at my disposal, and would serve no useful purpose. Accurate descriptions and directions for the operation of these machines may be obtained from their makers, gratis.

Cleanliness and careful lubrication are among the most important factors in the operation of a projector. Dirt and dust abrade the wearing surfaces of the delicate part and hasten the end of the machine's life. The effects of dirt are more noticeable on a projector than on almost any other machine owing to the delicacy of the adjustments and the closeness of the fits. Lack of oil also destroys the wearing surfaces, with even greater rapidity than dirt.

Excessive oiling is to be avoided, however, as carefully as the other extreme, for a projector dripping with oil is not only mussy and increases the amount of dirt collected, but is likely to ruin the film by throwing oil spray into the gate and magazines. A good grade of medium gravity oil should be used and should be applied sparingly and often, a drop at a time. All of the working parts should be flushed out occasionally with gasoline to remove the gum and sediment left by the repeated oilings. Wipe carefully into all of the corners and crevices with an old cloth that is free from lint and make sure that no metallic particles or grit remain.

There must be no lost motion between the parts of the intermittent motion, particularly between the star and wheel, for lost motion at this point is one of the most common causes of jumping. In taking up the lost motion between the star and wheel be sure that there is no binding, just an even free motion without appreciable "back-lash" or play.

This adjustment is made in the majority of machines by means of an eccentric bushing on the intermittent shaft. The hole for the shaft made in the bushing is slightly out of center with the hole in which the bushing fits so that by rotating the bushing it is possible to raise or lower the wheel in regard to the star. After adjustment the bronze bushing is held securely in place by means of set screws. When the bushings become

worn they should be immediately replaced with new bushings.

When the shaft is supported by more than one eccentric bushing care should be taken to turn them both through exactly the same angle. If this is not done, the shaft of the star and that of the wheel will be no longer parallel, which will cause binding to take place between the two engaging surfaces.

The pin and star should be watched carefully for wear and should be replaced as soon as lost or irregular motion becomes apparent. While these parts are made of carefully tempered steel they will wear in time and will eventually cause jumping.

FIRE ROLLERS.

To prevent the flame of an ignited film from entering the upper magazine, the outlet is provided with two sets of fire rollers and a connecting trap between which the film passes on its way from the magazine. Should the flame creep up to the outlet, the pressure of the rollers on the film would smother the flame.

The rollers should be kept free from deposits of emulsion dust to prevent scratches or an increased danger of fire. This dust also tends to clog the rollers and hold them open.

CARE OF THE UPPER FEED SPROCKET.

The upper feed sprocket which pulls the film from the upper feed reel is generally in the form of a hollow drum, equal in width to the width of the film. At either end of the sprocket are inserted the sprocket teeth that engage in the sprocket holes on the margin of the film. These teeth are generally set in the center of a raised ring that corresponds to the width of the film margin and which raises the picture space from the face of the sprocket drum. On several types of projectors, flanges are provided at the ends of the sprocket to prevent the film from jumping.

One or more rollers are placed next to the sprocket, which hold the film on the sprocket and in engagement with the teeth. These guide rollers are hinged on a spring bracket so that they may be dropped out of the way when threading the projector, and are also provided with an adjustment by which the distance of the

guide roller from the sprocket may be regulated. This roller should be about two thicknesses of film from the face of the sprocket to prevent the film from climbing or jumping over the teeth. If the rollers were to bear the film directly on the sprocket, the film would be likely to climb, especially at the time of a passing patch.

All emulsion dust and dirt should be removed from the sprocket as fast as it is deposited, that is, at the end of every run; if this is not done regularly, the deposit will increase until it reaches and scratches the surface of the film. The teeth of the sprocket should be examined for wear, and if worn or ridged, the entire sprocket should be replaced by a new one to prevent trouble from climbing or jumping.

THE INTERMITTENT SPROCKET.

The same remarks apply to the care of the intermittent sprocket in regard to dirt or wear, but it should be remembered that even greater care is necessary in the case of the intermittent as it has a more direct influence on the steadiness of the projection. The intermittent pulling of the latter sprocket wears small cuts on the under side of the teeth which cause occasional slips and mis-frames of the film.

The dust may be easily removed from the teeth of the sprocket by means of a small stiff tooth brush. Jumping is often caused by accumulations of dust that become packed on the surface by the continual passage of the film.

CARE OF THE GATE AND TENSION SPRINGS.

The purpose of the gate and tension springs has already been described in this and preceding chapters. In this article we will confine our attention to its care and maintenance.

At the top of the gate is a guide roller for feeding the film as it comes from the upper loop so that it does not slip to one side of the springs in passing through the gate. The roller is generally held in position on the spindle with a light coil spring allowing a very small sidewise movement of the film. On some machines this roller is made in two parts.

The film now passes between the tension spring of the gate and the aperture plate. The tension springs are one of the most important parts of the machine.

Their duties are two in number; to flatten the film against the aperture-plate, and to keep the film stationary while being projected. The film when being pulled down by the intermittent sprocket always has a tendency to keep moving after the intermittent movement has come to rest. The pressure of the springs overcomes this motion, keeping the film still while being projected, thus insuring a steadier picture on the screen.

These springs usually consist of thin strips of hardened steel. To secure an absolutely sharp picture all over the entire screen the film must be absolutely in one plane, or in other words flat against the plate. Film always has a tendency to curl up and the springs must exert enough pressure on the film to straighten it. The springs can be made to bear more tightly against the film by driving the screw on which the gate latch is fastened further in. This in reality brings the whole gate closer to the plate when the gate is closed. This adjustment is not as even as it might be, as the hinged side remains stationary.

The spring must be watched for wear, as the film wears long grooves in them, and they should be renewed when in this condition, or the film will not be in one plane as before mentioned. Do not tighten the springs so hard that the machine runs hard, as this will only cause undue wear on them. If the intermittent movement is in correct adjustment the springs will not have to be too tight to obtain a steady picture.

Tension springs should be kept clean from any gelatine which may come from the film. This is especially true of new film. Wipe the springs off with a rag that has been dampened in oil.

The cooling plate on the front of the gate absorbs all of the heat from the light which does not go through the aperture. This plate being about ½ of an inch from the gate shields it from the heat, thereby reducing danger from fire.

The aperture plate against which the tension springs press the film usually has two tracks on it about the width of the tension springs and slightly elevated above the surface of the plate. In this way the springs press only the edges of the film, or that part on which the sprocket holes are, against the plate. Thus the surface

of the film does not touch the plate itself and will not be scratched up in passing over it.

The constant pressure of the tension springs pressing the film against the plate has a tendency to wear the tracks of the plate. Especially when the springs are short a depression is worn on that part of the track on each side of the aperture. When the track becomes worn in this way a new plate should be installed as a sharp focus cannot be obtained with a plate in this condition.

THE TAKE-UP.

The take-up mechanism rotates the take-up reel on which the film is wound after passing through the gate.

A take-up will work satisfactorily if a little attention is given to it occasionally. During the beginning of the reel the take up reel must revolve very much faster than at the end, on account of the size of the reel. For this reason a friction drive is necessary. A belt or a coil spring generally drives the pulley on the take-up from the pulley on the machine. The belt must be kept tight enough to positively pull the reel, but a belt too tight will not work satisfactory, as it will not slip easily when the lower reel is almost full. The belt must be cleaned occasionally as dirt and oil from the machine are liable to get on it. On the Motiograph the flat take-up belt is adjusted by an idler. On the Power's, Edison, and the other machines the spiral spring on the shaft tightens the tension.

THE SHUTTER.

The shutter is primarily designed to cut off the light from the lens while the film is in motion. It can be seen that for a fraction of a second the illumination will be cut off from the screen. This dark streak across the screen, if it occurs in intervals far enough apart, will be very noticeable to the eyes. If we turn the crank fast enough this flicker can be overcome, but the action on the picture would be too rapid to be natural. Therefore, a second blade or interrupter has been added to the shutter.

The black interruptions now occur twice as often as before and are consequently not as noticeable. In order to reduce the flicker still further the three-blade exterior shutter has been designed. In this type one blade cuts off the light while the intermittent is in motion and two

interrupter blades cut off the light while the film is at rest. This naturally results in quite a loss of illumination as the light is cut off from the lens about one-half of the time. This style of shutter is desirable when a short focus lens is used. The exterior shutter should always be placed as close to the lens as possible.

When using alternating current of 60 cycles, the three-blade exterior shutter sometimes proves objectionable, owing to the fact that at times the alternation of the current is liable to run synchronously with the interruptions of the shutter in such a way as to cause the light on the picture to flare up and down. In this case the interior shutter must be used as it has but one interrupter. In the interior shutter the interrupter blade is made as narrow as possible so as not to cut off two much illumination.

When white streaks follow white objects (called "travel ghost") on the screen, as for instance in a white title against a black background, you may know that your shutter is not in correct adjustment. Setting the shutter is comparatively easy if you keep the object of it in mind. To set the shutter it must first revolve loosely on the shaft. Then get one of the film pictures exactly in frame by looking through the aperture. Turn it around until the pin starts to enter the star wheel; then the wide blade of the shutter should begin to cover the aperture.

Another method of setting the shutter is as follows: Turn the machine over until the dividing line between two of the pictures is exactly half way across the aperture. Draw a center line across the wide blade of the shutter, loosen the shutter, and turn it so that the center line is exactly in the center of the aperture, or horizontal. This is the correct shutter position. Tighten the shutter on the shaft. In both the cases just mentioned, the framing device should be central before attempting to set the shutter.

STARTING THE PROJECTION.

Always start the machine very slowly especially with a short leader or title, to prevent the audience from losing the title.

After threading up the film, before turning on the light, look through the aperture to see if the picture is

in frame. In this way you will not have to frame up or down as soon as the light strikes the film; it makes a better impression on the audience if the picture starts right at the beginning. If the title is short, as it usually is, this is doubly necessary as too much title and time is spent in framing up. If the lever is in the middle of its travel it will be easier to move it up and down than if it is at the top or bottom.

To save trouble during the performance, the operator should carefully examine the film before starting the projection. All loose patches, short leaders, and broken sprocket holes should be repaired.

REWINDERS.

The use of rewinders is compulsory in many cities, and is always desirable in any case. It can be used in a separate room or in the operator's booth according to the local requirements.

A machine of this type consists of a case 30 inches long, 15 inches high, and 3 inches wide, and is made of 1-16 inch seamless sheet steel. A flange door makes the case absolutely fire proof when closed. By an ingenious arrangement the reel spool is placed on a central shaft where it is permanently locked by a spring attachment from turning. When the door of the case is tightly closed and latched, a lug on the door presses the spool down and engages it with a locking device on the motor drive mechanism, and it is only then that the spool can be revolved.

When the door of the case is tightly latched, the entire case is necessarily fireproof and since the rewinding can only be done with the door latched there is no opportunity for carlessness to cause a fire.

A small motor is gauged to a speed which will tightly rewind all film 1,000 feet per minute without further attention and the company claims the entire cost of such rewinding for the average theater will not exceed five cents per week.

STEREOPTICON AND SONG SLIDES.

To get a sharp picture evenly illuminated all over the entire screen, the centers of the condenser and projection lenses should be in the same straight line. When the center of the lenses is very much higher than the cen-

ter of the screen a keystone picture results, that is a picture with the top wider than the bottom. This can be corrected by tilting the bottom of the screen forward. Another way to correct this is to make a mask or mat of sheet metal with the bottom wider than the top. This keystone mask should be fitted in front of the slide carrier. The slope of the sides will counteract the lines on the screen producing a picture whose sides form a perfect rectangle on the screen. This mask must be carefully made the slope of the sides having the same angle as those of the picture.

In running slides with a single lantern it is not very pleasing to see a slide move sideways across the screen and another take its place. For this reason the light is generally cut off from the lens while the slide is being changed. If the "dowser" or light shutter is attached to the condenser mount it may be dropped in front of the condensers when changing slides. An ordinary round fan attached to the wall below the projection lens will serve to cut off the light while changing slides. Grasp the fan by the handle and flit it quickly across the lens, while moving the slide. The slip-slide carrier is sometimes used. In changing, one slide is pushed past the other one causing a blur on the screen.

Most city ordinances require that the slide carrier be made of metal instead of wood. Small knobs should be fastened to each side of the carrier, so that it may be pushed or pulled as the case may be, making it unnecessary for the operator to reach over the light to move the carrier. When removing the slide and dropping in a new one be careful that you do not shake the slide carrier causing the slide to jiggle on the screen.

To obtain the best results in running slides you must have a dissolver. Passable results may be produced with various devices to cut off or dim the light while changing the slides, but the double lamp dissolver is the best.

In the double dissolver the equipment of both lamps must be the same. Each lamp should have a separate rheostat so that the resistance in each line is the same, giving each lamp the same amount of current. The condensers should have the same focal length so that the circle of light will be the same at the projection lens opening, when both lamps are at the same distance from

the lens. The lower lantern should be equipped with a double slide carrier, so that it may be used for running the slides alone in case the upper lantern becomes out of order.

It is very necessary when dissolving that the outside lines of the pictures remain in the same straight line. This is impossible with the ordinary song slides as the mats on the slides are not always placed the same. For this reason each carrier should be provided with a mask or mat having an opening slightly smaller than that of the slide mat. These masks should be lined up carefully and secured to the carrier and better results will be obtained.

The speed with which the dissolver lever should be operated depends very much on the slides. In changing views that are very dissimilar a quick movement of the lever is desirable, but where the scene changes but slightly the lever may be operated more slowly. Considering the general run of song slides it is better for the operator to work the dissolving lever faster than he usually does.

Not the least in producing good results is the projection lens. In order to get a picture whose corners are not yellow a half size lens should be used for all lenses over ten inches equivalent focal length.

The various slides should be kept in a long box with compartments furnished for the purpose. In this way an air space is around each slide giving it an opportunity to cool off. The danger of breakage is also reduced.

In running the slides each one should be placed in the same position on the table so that they may be picked up and dropped in the carrier without looking at each one before dropping it in. This is especially necessary when running with a dissolver, as two scenes somewhat similar following each other a certain bit of landscape may jump from one side of the screen to the other.

All of the slides should be cleaned each evening before the show by rubbing them off with wood alcohol using a clean rag. Care must be taken when changing the slides so that the slide is touched only on the border and not in the middle, as a finger print will surely be left on the slide. This is objectionable, to say the least.

In many shows a spot-light is used for the singer.

The audience will usually pay more attention to the singer and the song if a spot-light or some other illumination is used on the singer than if the house is in a darkened condition.

The round spot is probably the best to use. A spot can be made for the head only or for the whole figure. There are various ways to make spots. A glass slide is sometimes used. Cut out a circle from black paper, making the hole about three-quarters to one inch in diameter, being sure to cut the edges sharp otherwise the spot will be fuzzy. Place the paper between two slides and bind temporarily. Place the slide in the carrier and locate the spot correctly with reference to the singer's position on the stage. Then bind it permanently. This slide will not stand much heat and if a spot is used steadily, one made of tin or sheet metal will serve the purpose better. If a tin slide is used the top of it can be hinged to the top of the condenser mount and when not in use it can be swung up out of the way.

Colored spots are often desirable, and can be obtained either by the use of colored gelatine slides or the disc with different colors of gelatine.

ANNOUNCEMENT SLIDES.

Neat announcement slides give a certain style or character to a show. For the regular announcement slides used every performance, it is better to have a permanent slide such as are manufactured by the various novelty slide manufacturers than a hastily home-made slide.

To announce coming features and other things, where the slide is to be used for one or two nights, several methods can be used to make the slides. One of the simplest slides can be made by writing with waterproof ink on a plain glass slide. This gives black letters on a white field. Use Higgins or some other waterproof black ink and a small fine pen or brush. This is perhaps the quickest made of all slides. A piece of colored gelatine bound between two cover glasses, one of the glasses bearing the announcement, will give a different colored field and will not be so glaring as the white field.

Announcements can be typewritten on thin paper and then bound between two cover glasses. Intensifiers

dusted on these announcements bring out the letters more clearly.

PRIVATE LIGHTING PLANTS.

Owners and managers of moving picture theaters have their share of tribulations, and the obtaining of suitable electric current at reasonable prices is not the least of their trouble. Alternating current is not well suited for moving picture work, and under many conditions is almost intolerable, especially in the lower cycles, with its ceaseless flicker, as well as in the large number of instances in which the regulation is poor. Direct current with good regulation, at the proper voltage, and at a reasonable price, is ideal, but almost never obtainable. In most of the smaller cities, and many of the large ones as well, the station equipment is inferior or poorly looked after, and the result is a variation of from 10 to 20 per cent in the voltage. This is particularly true of those stations which furnish electrical energy for street car and power service. So much for regulation. As to proper voltage, a moving picture lamp requires only forty to fifty volts at the arc. Allowing for resistance, an input of sixty volts is ample; but the current supplied by lighting companies is never under 110 volts, and from that up to 220 volts, so that from one-half to three-quarters of the current paid for is wasted in the rheostat. This is a serious question. One of the principal items of expense of a moving picture theater is the electric current. The attitude of lighting companies in most towns, both small and large, towards the moving picture theater is most aggravating. They figure, with much shrewdness, that the theater must have electric light, and usually push prices up to the last notch. It is not unusual to find a theater using 1,000 to 1,500 k. w. monthly, charged at the rate of 12 to 15 cents a k. w., while an auto garage, saloon, or butcher shop a few doors away is paying from 3 to 5 cents per k. w. on a consumption of one-tenth as much. In very many of the smaller towns a serious loss to the show owner lies in the inability to get current in the day time, which cuts into his possible revenue to the extent of 20 to 40 per cent. Revolting against these conditions, many owners have within the past year or so put in their own electric light plant, thus cutting the cost of current materially.

At the present time there are several makes of gas engines that are specially built for motion picture work. They operate equally well on illuminating gas, gasoline, kerosene or crude, and are capable of materially reducing the expenses of the show. The voltage of the generator, which is direct connected to the gas engine, is usually about 60 volts, so that the rheostatic losses at the lamp are reduced to a minimum. An engine of this type is illustrated by Fig. 52a, direct connected to the generator

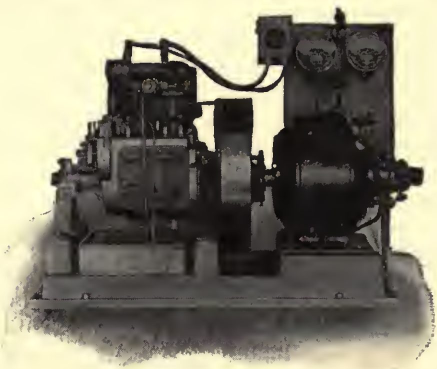


Fig. 52-A. Direct Connected Engine and Generator.

shown at the right. The switchboard containing the switches and measuring instruments is shown at the rear of the generator.

The floor space occupied by the outfit is small, and the machine requires but little attention. Nearly any of the attendants about the average show will be able to operate the plant after a few instructions.

THE OPERATOR'S BOOTH.

The importance of the operating room, its equipment, and its occupant should receive the most careful attention of the exhibitor, because, with the screen, it is the vital part of the theater. It must be directly opposite the screen upon which the pictures are projected, either in front or back of it. As most of the screens are located on the rear wall of the theater, the operating room is necessarily placed near the front end, generally over the entrance or lobby of the theater. The

only objection to this is that in case of fire the audience would have to run a gauntlet of flames to get out unless there were other exits. But with the many safety devices offered by the modern machine, and the care with which the films are handled, fires are of extremely rare occurrence and seldom do they get beyond the operating room.

Formerly all operating rooms were covered with sheet metal inside and out, but now other fireproof materials are more generally used, giving more satisfaction. If it is necessary to use sheet metal the studding should be first covered with asbestos board ¼ inch thick, over which the sheet metal may be nailed. Nail the metal securely to the studding so that there will be no danger of the seam's opening up.

Hollow terra cotta tile 4 inches thick, makes the best fireproof material. It may be laid up easier and in less time than concrete. Holes are easily broken through the tile for peep holes.

Other details relating to the construction of the booth can be found in Chapter V.

Secure your machine thoroughly to the floor by embedding strips in the concrete; or if you have an iron floor nail two wood strips of 1x2-inch stuff on the floor in which you have drilled holes for the four legs of the machine. Brace the legs with wire and your machine will be solid. The lamphouse should be grounded by fastening a wire to it and running the wire to a water or waste pipe, not a steam pipe. This may save you an unpleasant shock. In placing the machine, put it far enough back from the front wall of the operating room so that the operator may place his chair opposite the head instead of opposite the lamphouse. In this way he will not get as much of the heat from the lamp, and his eyes will not be injured by looking at the bright spot on the gate.

It is better not to have the operator's chair or stool secured to the floor, so that it may be pushed out of the way when necessary. When possible it is better to have the machine high enough from the floor so that the operator may stand up occasionally to run his machine, as sitting down on a stool on a long run is somewhat tiresome.

The rheostat or transformer should be placed on

the opposite side of the machine from the operator, near the lamphouse. If you are using alternating current, use a transformer, as it will not only reduce your light bills, but will not give off near as much heat as the rheostat. It is a good idea to have an extra rheostat connected on the line, so that during a long run you can switch on the extra rheostat when the first becomes heated, thus allowing it to cool off.

The knife switches for the machine should be enclosed and installed so that accidental contact cannot be made. A separate switch should be used for each lamp and a main switch to turn off both lamps if a dissolver is used. Only double pole-knife switches should be used for arc lamps. Place the switches so that the operator may reach them when sitting at the machine. A switch to control one of the house circuits may be placed in the room so that in case of accident some one of the house lights may be switched on.

A rubber mat should be placed on all iron floors upon which the operator may stand or place his chair without danger of a shock.

The rewind should be located near the machine, so that if necessary the operator may rewind the films while running the machine. This is bad practice, but must be put up with once in a while. The laws in some cities prohibit rewinding in the operating room; in such cases the rewind is generally located in the workroom. There should be three or four empty reels for use in the machine kept in the room, which have perfect springs and run true. These should be marked and not taken out of the room.

A metal case with compartments for three or four reels should be placed handy to the machine near or on the floor. All films when not in use should be kept in this case. A metal case should be used to keep leaders and scraps of film. Never leave any film lying exposed on the floor, no matter how small a piece.

A shelf should be placed near the machine, upon which to keep song slides, cement and other articles in constant use. In some cities all shelves must be covered with metal.

The work bench may be placed in the operating room, or better, in a separate room with a large window

in it. There is always more or less tinkering to be done in a theater, and a separate workroom is very convenient. The bench should be substantially made of two-inch plank and equipped with a small vise.

Two or three outlets for lights with cords should be in every operating room; one over the machine, one near the rewind, and one to light up the room in general. The incandescent lights should be protected with wire guards. An outlet should be provided for a fan.

Bells and push buttons to signal to various parts of the house should be located near the operator. A speaking tube or small telephone should be placed conveniently so that the operator may speak to the manager.

A stock of fuses of the various sizes should be kept on hand. Wire for incandescent lighting and an extra set of asbestos-covered wire with connection terminals fastened on ready to attach.

BELLS AND BUZZERS.

Any number of bells and buzzers may be rung from one battery of a couple of dry cells if the wiring is properly arranged. Furthermore, there need be no trouble whatever in the addition of another bell and button to the system at any time if the rules for such systems are understood and correctly followed in the first wiring.

To wire your buzzers correctly get three colors of No. 18 wire. What is known as double-cotton-covered paraffined annunciator wire is the cheapest that is good enough. This is copper wire of No. 18 B. & S. gauge, wrapped with two layers of cotton thread, the thread being wound on in spirals. The spiral of the outer layer is in the reverse direction from the spiral of the first layer so that the threads constantly cross.

When no more than two or three cells of a battery are used, the wires may be fastened to the woodwork with staples, placing only one wire under a staple. When a number of wires are run together, they may be placed under wooden cleats or in a wooden electric-light moulding. On outdoor work, rubber insulation should be used because of the moisture.

There are to be three colors of wires, one color for common bell wire, one color for common push button wire, and one color for individual wires. The diagram shown by Fig. 53 gives the "code" or explanation of the

diagrams that are to follow. It will be noted that each color of wire is indicated by a different kind of line. The actual colors may be anything that is convenient as the colors are simply used to designate the part that they play in the circuit. In selecting the three colors, the name of the colors may help the memory if they are properly chosen. Supposing that red wire, white wire, and blue wire represent ringer wire, button wire, and feed wires respectively, then we can tell their nature at a glance.

Take the wire selected for first color or common bell wire and run a single wire from the batteries to one of the binding posts on each of the buzzers and bells; not a wire to each, but a single wire, running from one to another until all are connected at one binding post only.

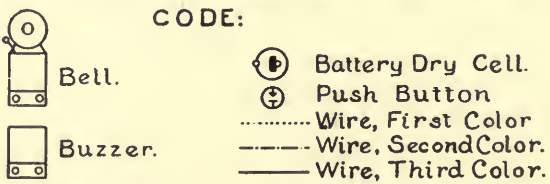


Fig. 53. Bell wiring. Symbols for drawings.

The ringer wire may start from the battery in several directions if that is the most convenient way to reach all of the bells and buzzers.

CONNECTING THE BATTERIES.

Connect the two cells of the batteries together, the zinc of one to the carbon of the other, as shown in the diagram, and connect the common ringer wire, first-color wire, to one of the free binding posts of the battery.

It makes no difference which of the binding posts of the battery or which of the binding posts of any bell or buzzer is connected to the first-color wire; the rule is that first-color wire must connect to one side of every annunciator device and to one side of the battery.

CONNECTING THE PUSH BUTTONS.

Now take the second-color wire, or "push-button wire," and, starting from the remaining binding post of the battery, run to one side of every push button, taking the buttons in any order just so the second color wire gets to all of them.

It makes no difference which of the button springs the wire is connected to; the rule is that the second color wire must connect to one side of every button and to one side of the battery.

CONNECTING THE SIGNAL WIRES.

Both sides of the battery now are connected and every buzzer and every button has one side connected. Next comes the running of the individual signal wires, or third-color wire.

The rule for the third-color wire is that each push button must be connected by a separate individual third-color wire to the bell, buzzer or annunciator which that button is to ring.

Run the third-color wires one at a time. In each case you will find a second-color wire already on the push button, and to the remaining spring of the push button connect your third-color wire, then cut it to the proper length, put it in place neatly and see that the other end of it reaches the bell or buzzer which that push button must ring. One of the binding posts of this bell or buzzer already has a first-color wire, and when you have connected the third-color wire in the remaining post of the bell a push upon the button will ring that bell, and no other. This is true, no matter how many buttons and bells are connected up to the one battery.

In this system, each bell and button has but a single wire, which belongs to that bell and button alone, and the total number of wires used is absolutely the smallest which will do the work. In addition to the single wire, which is third color, each bell is reached by the common first-color wire, and each button is reached by the common second-color wire.

ADDING A BELL.

To install an additional button and buzzer upon a system correctly wired as above proceed as follows:

Test the buzzer and mount it where desired; mount the push-button where desired.

Get a piece of first-color wire and run it from one binding post of the buzzer to any first-color wire already in use; preferably this is from the nearest bell or buzzer, or possibly from the battery, but this new first-color wire may be attached to any first-color wire anywhere that such a wire can be found.

Get a piece of second-color wire and run it from one of the springs of the new button to any second color wire. If the new button goes in beside an old button a few inches of wire is all that is needed.

Get a piece of third color and connect the remaining spring of the new push button to the remaining binding post of the new buzzer, and the new push button will ring the new buzzer.

THE DIAGRAM.

The wiring diagram shown by Fig. 54 shows an arrangement for a small theater where the program is conducted by the door-keeper. The "Code" will explain the meaning of the different parts of the diagram, and from this it should be easily understood.

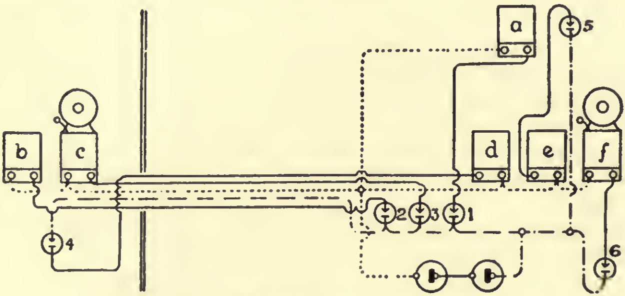


Fig. 54. Bell wiring. A complete system.

In the diagram, button 1 will ring buzzer a and no other; button 2 will ring buzzer b; button 3 will ring bell c; button 4 will ring buzzer d; button 5 will ring buzzer e; button 6 will ring bell f.

In this arrangement, the door keeper is in position to control the program of the show. The door keeper has buttons 1, 2, 3, buzzers d, e, and bell f. In the retiring room behind the stage are buttons 4, buzzer b, and bell c. In the picture operator's booth are button 5 and buzzer a. Button 6 is in the cashier's booth and is an emergency call from her to the door-keeper.

SPECIAL CONDITIONS.

While this covers all conditions usually met in bell wiring for small theaters, yet there are special conditions likely to be met at any time, and three of them will

be taken up in detail. These are (1) the ringing of one bell from several buttons, (2) the ringing of several bells from one button, and (3) special battery conditions for long lines of wiring.

ONE BELL FROM SEVERAL BUTTONS.

Taking up first the ringing of a single signal device by two or more push buttons, the circuits for a buzzer and three push buttons are shown in diagram in Fig. 55. The method of wiring is as follows:

Having mounted the buzzer and the three buttons where desired, take a piece of wire of the first color of

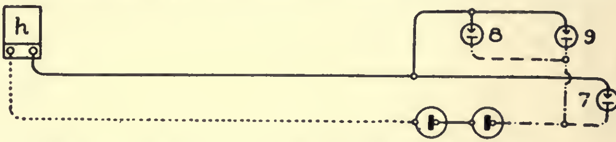


Fig. 55. Bell wiring. Several buttons to ring one bell.

the color scheme, and connect either binding post of the buzzer to the side of the battery which already has connected to it a wire or wires of the same color as the wire being used. Next, take a piece of wire of the second color of the color scheme and connect the remaining side of the battery (which already has wires of the second color attached to it) to one of the springs of each of the three push buttons. This may be done by running the wire from the battery to one of the springs of one of the buttons and then from that spring (leaving the other spring of the button empty as yet) to one of the springs of each of the other buttons; or, if more convenient by reason of the locations of the buttons there may be two or three of the second color wires, leaving the battery in different directions, and going independently to the two or three or more buttons which are to ring the buzzer. In any case, each button has an empty spring left upon it, after the second-color wires, or battery wires, have been connected.

Now take a third-color wire and begin at the buzzer. Attach the third-color wire to the remaining binding post of the buzzer, and run to the most convenient of the buttons, attaching to the remaining spring of that button. To reach the other buttons, a third-color wire is used, but it may be run either from the buzzer or from

the button which was connected first, or from any point on the third-color wire first put in between the buzzer and the first button. The running of the wire from an intermediate point is not desirable, because of the joint which must be made, unless it is inconvenient to run it either from the buzzer or from the first button.

ADDING A BUTTON TO SYSTEM.

In adding a second button to a system which is already in operation, to have the new button ring a buzzer which is ringing already from one button, the simplest method of all is just to run two wires from the old button to the new one; in doing this, however, if

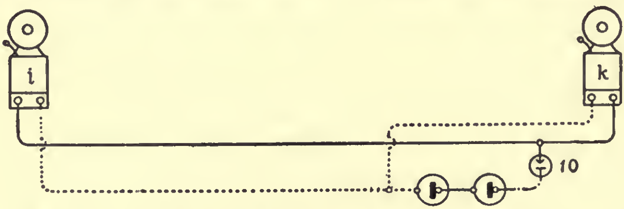


Fig. 56. Bell wiring. Two bells from a single push button.

your complete installation was put in properly with three colors of wires, then the new wires should be carefully placed to match the right colors, otherwise trouble will result when making still further additions to the system, later.

TWO BELLS FROM ONE BUTTON.

Another and fundamentally similar case arises when it is desired to ring two bells or buzzers from the same push button. This case is illustrated in Fig. 56. In that diagram the bells are widely separated and the button is near the battery. From the battery two wires of first color run to the two bells independently; a short wire of second color runs from the battery to the button, and from the second spring of the button two wires of third color run independently to the second binding posts of the two bells. Care should be used in connecting up this arrangement according to the color code if any three colors of wire can be obtained.

Little difficulty ever is experienced in ringing two bells from one push button, but when more than two are required to be rung a special battery arrangement may

be required. The reason that two bells seldom give any trouble is that two bell tappers will strike alternately. The principle of the vibrating bell is that when it is pulled up by the battery current it breaks its own circuit and stops the current, the tapper then falling back while the circuit is broken and the current is not flowing, but when the tapper falls back it closes the battery circuit and is pulled up again. The second bell, therefore, gets the full force of the battery, while the first bell is in its striking position and the second bell pulls up and taps while the first bell is falling back. Thus, two bells will take "turn about" with the battery and will ring satisfactorily, even though one of them be at a considerable

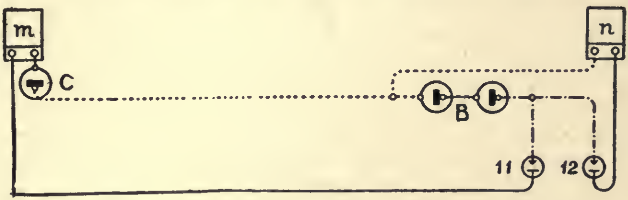


Fig. 57. Bell wiring. A booster battery.

distance from the battery and the other very near (the worst possible condition, for the nearer one tends to "rob" the battery current from the far one).

THE PROBLEM OF LONG LINES.

Another condition requiring special treatment is that in which one of the bells or buzzers of a system is located at a very much greater distance than the remaining ones. A push button at a distance involves the same trouble and is cared for by the same remedy. This condition is shown in the diagram of Fig. 57.

The buzzer *n* and the buttons 11 and 12 are located near the battery *B*. The buzzer *m* is at a distance so great that it does not ring satisfactorily with the two cells of the battery *B;* yet if three cells are used at *B* the buzzer *n* makes more noise than is agreeable, and, furthermore, the batteries deteriorate more rapidly because of the greater current taken.

A BOOSTER CELL FOR LONG LINES.

The solution of the trouble is to put an additional battery cell in the circuit for the buzzer *m* without in-

cluding it in the circuit for the buzzer *n*. This is done by placing the extra cell either at the buzzer or at the button which rings it. The cell may be placed in the third-color wire, but preferably is placed in the first-color wire if placed at the buzzer, and in the second-color wire if placed at the push button. Buzzer *m* now rings through three cells and buzzer *n* rings through two cells.

The added cell is called a "booster." In installing a booster cell the carbon terminal of the booster cell must be connected to the zinc terminal of the cells of the main battery, or the zinc of the booster to the carbon terminal of the main battery. It having been decided that the booster cell will be put in at the buzzer, and therefore that it will be put in the first-color wire, notice that the first-color wire at the battery is connected to the edge binding post of the cells; then at the buzzer connect the first-color wire to the middle binding post of the booster cell, connecting the edge post of the booster to the buzzer. This connects the middle post of the booster to the edge post of the main battery, or carbon to zinc, as required. If, on connecting in a booster cell the buzzer does not ring try reversing the booster by transposing the wires at its binding posts.

THE BATTERY FOR THE LINE WIRING.

In a bell and buzzer system the amount of battery required depends upon the length of the lines. An ordinary bell or buzzer is made to ring on one cell, and it should pass this test before it is put up for use. However the wire which is used in the circuit will take some of the power of the battery, and usually one extra cell is used to provide for waste of power in the wiring; one cell for the wiring and one cell for the bell. When the line of wiring is long, one cell may not be enough for the wiring and two or three must be used.

In the case of Fig. 57, therefore, the use of two cells for the buzzer which is near the batteries and three cells for buzzer which is more distant from the batteries does not in any way indicate that the buzzer requiring the three cells is not as good a buzzer as the one which works on two cells.

Were the buzzer near and the button distant from the battery the result would be the same; it is the length

of the wiring which causes the hardship and requires the additional battery cell.

IMPORTANCE OF THE COLOR CODE.

The system of color-code for the wiring of bell and buzzer system should be understood and used in wiring any system of signaling circuits which has more than a single buzzer or a single button. The saving in time when something goes wrong with the system, whether from an earthquake or from a mouse's gnawing a wire in two, will repay all the trouble involved in putting in the system of wires properly at first.

CHAPTER VII.

TYPICAL ORDINANCES AND SPECIFICATIONS GOVERNING MOTION PICTURE THEATERS. REMARKS ON VENTILATION.

As a guide to prospective owners and managers of picture shows who desire general information in regard to the typical requirements of the municipal authorities and the board of Fire Underwriters, I have abstracted a number of clauses from the laws and regulations of these bodies. In no case do the excerpts cover the entire requirements of any one city—for this would take far more space than the entire subject of motion pictures—but it will give the builder an idea of the conditions that he is generally called upon to meet, and thus will afford him a basis on which to make his calculations in regard to the construction and operation.

Following this will be found a few remarks upon the subject of ventilation—a most important feature of the modern picture show, and one which is in constant dispute by local boards of health and private improvement associations.

CONDUCT OF THE SHOW.

A special commission appointed by Mayor Gaynor of New York, submitted the following ordinance on November 4, 1911. The portions of the ordinances quoted cover more particularly the operation of the theater than its construction:

SUB-SECTION "F".

I.—Lighting—Every portion of a motion picture theater, including exits, courts and corridors, devoted to the uses of accommodation of the public, shall be so lighted during all exhibitions and until the entire audience has left the premises, that a person with normal eyesight should be able to read the Snellen standard test type 40 at a distance of twenty feet and type 30 at a distance of ten feet; normal eyesight meaning ability to read type 20

at a distance of twenty feet in daylight. Cards showing types 20, 30 and 40 shall be displayed on all four walls, together with a copy of this paragraph of the ordinance.

II.—Heating—When the temperature of the outdoor air is below 60 degrees Fahr. the air in the theater, while an audience is present, shall be maintained at a temperature of not lower than 62 degrees Fahr. or higher than 70 degrees Fahr.

In heating motion picture theaters, no gas stoves, oil stoves or other apparatus throwing the products of combustion into the air of the theater, shall be used.

III.—Ventilation—Motion picture theaters having less than two hundred cubic feet of air space for each person, or motion picture theaters in which the outside window and door area is less than one-eighth of the floor area, shall be provided with artificial means of ventilation which shall supply during the time the audience is present, at least five hundred cubic feet of fresh air per hour for each person.

Motion picture theaters having more than two hundred cubic feet of air space for each person, or which have outside windows and doors, the area of which is equal to at least one-eighth of the floor area, shall be provided with artificial means of ventilation, which shall be in operation when the outside temperature requires the windows to be kept closed, and which shall supply during the time the audience is present, at least five hundred cubic feet of fresh air per hour for each person. When the artificial ventilation is not in operation, ventilation by means of open doors and windows shall be sufficient to provide each person with five hundred cubic feet of fresh air per hour.

Motion picture theaters having more than one thousand cubic feet of air space for each person and having outside windows and doors, the area of which is equal to at least one-eighth of the total floor area, shall not be required to have artificial means of ventilation, provided the air is thoroughly changed by freely opening doors and windows immediately before the admission of the audience, and at least every four hours thereafter.

No part of the fresh air supply required by any of the above paragraphs of this section shall be taken from any source containing vitiated air.

The area of outside doors and windows shall mean the area capable of being freely opened to the outside air for ventilation purposes.

When fresh air is supplied by means of ventilating openings, at least one inlet shall be situated at one end of the room, and at least one outlet at the other end of the room. Where exhaust or inlet fans are necessary, at least one of such fans shall be placed in an outlet opening. The inlet openings and their surroundings shall be kept free from two feet of the floor, and the outlet opening or openings in the ceiling or within two feet of the ceiling. The inlet openings and their surroundings shall be kept free from dust so that the incoming air shall not convey dust or stir up dust as it enters.

During the time the audience is present, the air in the theater shall be kept continuously in motion by means of fans to the number of at least one to every one hundred and fifty persons. Such fans shall be placed in positions remote from the inlet and outlet openings. No person shall be exposed to any direct draft from any air inlet.

The booth in which the picture machine is operated shall be provided with an opening in its roof or upper part of its side wall, leading to the outdoor air. When the booth is in use, there shall be a constant current of air passing outward through said opening or vent flue, at the rate of not less than thirty cubic feet per minute.

The specifications of the above paragraph shall apply to portable booths and booths in open air theaters.

SUB-SECTION "G".

Motion picture theaters must be kept clean and free from dust.

The floors where covered with wood, tiles, stone, concrete, linoleum, or other washable material, shall be mopped or scrubbed with water or swept with moisture, or by some other dustless method, at least once daily, and shall be scrubbed with water and soap, or water and some other solvent substance at least once weekly.

Carpets, rugs and other fabric floor coverings shall be cleaned at least once daily by means of suction cleaning, beating or dustless sweeping. Curtains and draperies shall be cleaned at least once monthly by suction cleaning, beating or washing. Cornices, walls and other dust-hold-

ing places shall be kept free from dust by washing or moist wiping. The wood and metal parts of all seats shall be kept clean. Fabric upholstering of seats and railings and their fixed fabrics shall be cleaned by suction cleaning, or other dustless methods, at least once monthly.

SUB-SECTION "H".

No child, actually or apparently under the age of sixteen years, unless accompanied by its parent or guardian, shall be permitted to enter any motion picture theater except that between the hours of 3 p. m. and 6 p. m. on days when the public schools are open for instruction and at any time up to 6 p. m. on other days, unaccompanied children under sixteen years of age may be admitted and allowed to remain not later than 7 p. m., provided:

I.—That there shall be reserved in said theaters during the above-mentioned hours for the exclusive use of said unaccompanied children, a part or section of seats which shall be at least three feet distant on all sides from all other seats.

II.—That said unaccompanied children shall not be permitted to occupy or remain in any place or space in said theaters other than said seats, and that during the above-mentioned hours no other person except the matron hereinafter mentioned, shall be permitted to remain within three feet of said seats.

III.—That at all times during the above-mentioned hours there shall be in attendance at each of said theaters a duly licensed matron who shall be paid by the licensee of said theater and who shall keep constant watch over said children and strictly enforce the provisions of this section.

Nothing contained in this section shall apply to exhibitions or entertainments given under the auspices of educational, religious and charitable institutions, provided that the proceeds thereof are used entirely for educational, religious or charitable purposes.

SUB-SECTION "I".

Matrons above referred to shall be women of good moral character, not under forty years of age, and shall not serve unless they have secured a license from the

Mayor. Said license shall not be transferable, and the annual fee therefor shall be five dollars.

Applications for matron licenses shall be made to the Mayor, and each application shall be accompanied by two photographs of the applicant, and shall bear the endorsement of at least two reputable residents of the City of New York, who shall certify to the character and qualifications of the applicant, and shall state the facts or circumstances by which they derived their knowledge.

The photographs herein referred to shall not exceed three inches in diameter, one of which shall be affixed to the application and the other to the license.

No person shall employ an unlicensed matron in a motion picture theater, and immediately upon employment of a matron the person employing her shall notify the Bureau of Licenses in writing, stating the name, address and license number of said matron.

NEW JERSEY BOOTH LAWS.

"State law booths" for New Jersey picture theaters must hereafter be used in all places where the films are shown. The requirements of local bureaus are now superseded by a state law.

The new law requires that booths shall be lined with "asbestos or other strong and fire resisting material" which shall be a quarter of an inch thick.

Other requirements in the new law are that the booths must not be less than forty-eight square feet in size and seven feet high. The Newark regulations provided for booths not containing less than thirty-six square feet, although many are much larger. There are other minor provisions in the state law that differ with those now in effect.

DETROIT CENSORSHIP LAWS.

Under a system adopted by the censorship board of Detroit, Mich., no film can be shown until it has first been inspected and a permit issued. The principal film concerns submit their films to the National Board of Censors before they are sent out, but notwithstanding, the exhibitor must submit it for a second inspection before the local board. The exhibitor must report to police headquarters, show the film, and get a written permit which must be kept in the theater. Any patrol-

man can then demand to see the permit, and if none is forthcoming, order the film discontinued.

SHOWS AND CHURCHES.

An ordinance prohibiting theaters within 300 feet of a church or school will be passed by the city commission of Omaha, Neb. This ordinance is now drafted. While some of the councilmen believed such theaters ought to be 500 feet from churches and schools, others declare 200 feet is sufficient. The question will be compromised and 300 feet fixed as the limit.

NO FRAME BUILDINGS IN OHIO.

No picture shows will be allowed to be installed in frame buildings in Ohio.

The law does not compel the tearing down of present frame structures, in which picture shows are given, but it does prevent the erection of new shows in any but brick or fireproof buildings. The answer is that the day of the frame show building is about over.

Even in the case of extensive repairs on present frame structures, the department of workshops and factories compels the use of fireproof material. For example, if a frame building is to be arranged for the placing of a new balcony in it, the entire balcony would have to be fireproof.

CENSORSHIP IN MILWAUKEE.

A tentative draft of the motion picture-film censorship ordinance has been devised for Milwaukee, Wis., in response to growing public demand.

It provides for a board of censorship to be appointed by the mayor, the members to serve without pay for a two-year term.

There are seven sections to the ordinance. The first forbids exhibition of any suggestive picture or one depicting murder, suicide, robbery, stabbing, clubbing, or beating of a human being. The second establishes the board of censorship and its secretary. The third forbids the exhibition in Milwaukee of any picture, unless it has been approved by the censors and affixed with a stamp, "Passed by the Local Board of Censorship." This section will not apply to pictures shown for purely educational, charitable or religious purposes

by fraternal, charitable, educational and religious associations, or by libraries, museums and schools.

PROJECTOR REGULATIONS.

An extensive set of specifications has been made for the Underwriters' Equitable Rating Bureau of Portland, Ore., by F. D. Weber, their electrical inspector. Parts of the specifications are as follows:

It is urged that, wherever possible, the moving-picture machine be located at the end of the room opposite the entrance, instead of at the entrance, as is usually the case.

The arc lamps used as a part of the machine must be constructed similar to arc lamps designed for theaters, as far as practicable, and the wiring to the lamp must, at least, be the equivalent in current-carrying capacity of No. 6 B. & S. gauge copper wire.

Wiring must all be in approved rigid or flexible conduit (this includes booth, auditorium, dressing rooms or any part of the moving picture theater). Each picture machine, dissolvers, flood or spot light must be wired as a two-wire circuit, and a two-pole switch and cut-out must be cut off and protect the resistance and arc for every machine. All conduits must be brought to a point as near as possible to the arcs of the machines. Connections from arcs to conduit must be made with asbestos-covered wire. Conduit must be rigidly supported in every case.

Rheostats or other necessary current-reducing devices must be made entirely of non-combustible material and of approved design. Must be mounted on non-combustible support in such a manner that there will be an air space of at least 3 inches on all sides. The rheostat must be of inclosed design or be completely inclosed by a netting with a mesh not greater than 0.5 inch. When the resistance is not hung in the operating room and the same is excessively hot, it must be properly protected by asbestos. It is strongly advised that resistances be suspended from the ceiling on straight insulators. When it is possible, the resistance should be located outside the booth.

Top and bottom reels must be inclosed in steel boxes or magazines, each with an opening of approved con-

struction at the bottom or the top, so arranged as not to permit the entrance of flame to the magazine. No solder is to be used in the construction of these magazines. The front side of each magazine must consist of a door having spring hinges and swinging horizontally, and provided with a substantial latch. An automatic shutter must be provided, and must be so constructed as to shield the film from the beam of light whenever the film is not running at operating speed. The shutter must be permanently attached to the gate frame. In addition, a non-automatic shutter must be provided, placed in front of the condenser, so as to be readily closed by hand.

Extra films must be kept in individual metal boxes equipped with tightly fitting covers.

Reels containing films under examination or in process of rewinding must be inclosed in magazines or in approved metal boxes similar to those required for films in operation, and not more than two feet of the film shall be exposed in the booth.

All booths must be at least 6.5 feet high, or high enough to provide space for gravity sliding doors, with floor space to vary according to the number of machines in the booth. The floor space for one picture machine alone must be 6 by 6 feet; for one picture machine and one stereopticon, 9 by 6 feet; for two picture machines and one stereopticon, 12 by 6 feet.

Openings per machine in the booth must consist of one for the operator and one for the machine. Opening for machine shall not be more than 8 inches high and 12 inches long. Operator's window shall be not more than 12 inches wide and more than 12 inches high. All openings in other portions of the booth, except ventilator in ceiling and entrance doors, must not exceed 8 inches wide and 12 inches high. All openings to this booth, excepting entrance doors to this enclosure house, must be arranged so as to be entirely closed by doors or shutters constructed in the following manner: Doors must be hung so that gravity will tend to close them (only vertical sliding doors will be approved) and be held open by a twine arranged in such a way that it will pass directly over the film when in place. All doors over openings, except entrance doors, must be sliding

doors, and be constructed of two pieces of No. 20 B. & S. gauge galvanized iron, one piece placed on each side of one-quarter-inch asbestos; lap 1 inch around the corners, and the whole riveted together. The doors must lap over all edges of openings at least 1.5 inches. The same must run in galvanized iron guides of at least No. 14 B. & S. gauge, the guides to lap over door at least 1 inch, and fit snugly against the openings covered. The guides must be placed inside of the booth and all the heads of nails or screws holding them in place must be concealed by a single lock formed on the guides. These guides must be continued across the bottom of the opening to form a seat for the door to drop into, corners of guides to be lapped and riveted.

Ventilation must be obtained through the ceiling in all booths to the outside air, and no ventilator to be of smaller size than 36 square inches in cross section per machine. The ventilator must be constructed with lock joints or rivets, and solder must not be depended upon for holding sheets of metal in place. The gauge of metal must be the same as used in the construction of iron booths.

Stationary wooden metal lined booth must be constructed of sheathing at least three-quarters of an inch thick, supported by 2 by 4-inch wooden studding, not more than 18-inch centers, presenting a smooth and solid surface on the inner side of booth. All studding, braces, etc., must be on the outside of the booth. The ceiling and walls of the booth must be lined with at least one-eighth-inch asbestos under galvanized sheet iron as thick as No. 24 B. & S. gauge, and the joints must be locked. The floor must be covered with galvanized sheet iron, at least as thick as No. 20 B. & S. gauge sheet iron over one-eighth-inch asbestos. The metal must be secured in position by nails and the heads of these covered by an approved lock joint, made with the metal linings of the booth. Entrance doors must not be larger than 2 by 6 feet.

VENTILATION.

A committee on standards for ventilation legislation presented the following report at the annual meeting of the American Society of Heating and Ventilating En-

gineers. This report makes recommendations for the *minimum* requirements.

1. Floor Area per Occupant.—A minimum of four and one-third square feet of floor area, as a seating space, per occupant, exclusive of aisles and public passageways, shall be provided in the audience hall.

2. Cubic Space per Occupant.—A minimum of 80 cubic feet of air space, per occupant, shall be provided in the audience hall.

3. Quantity of Outdoor Air.—A positive supply of outdoor air from an uncontaminated source shall be provided the audience hall at all times while the show place is open to the public and the quantity of this positive supply of outdoor air shall be based on a minimum requirement of 15 cubic feet per minute, per occupant.*

4. Temperature.—The temperature of the air in the audience hall shall at all times, while the show place is open to the public, be maintained throughout at the breathing line (persons being seated) within the range of 62 degrees F. to 70 degrees F. (except when the outside temperature is sufficiently high not to require the air supply for ventilation to be heated). The temperature, distribution and diffusion of the supplied outdoor air shall be such as to maintain the temperature requirement without uncomfortable drafts.

5. Direct Heat Sources.—Any good heat source which does not contaminate the air will be accepted to supplement the warmed outdoor air supply. Gas radiators are prohibited.

6. Machine Booth Ventilation.—Enclosures or booths for the motion picture machines shall be provided with special exhaust ventilation with a capacity to exhaust at all times not less than 60 cubic feet of air per minute through a one-machine booth, not less than 90 cubic feet of air per minute through a two-machine

*The ordinance in force in the City of Chicago at the present time requires that the air in the auditorium in the class of buildings in which motion picture show places are included, shall be changed so as to supply for each person for whom seating accommodation is provided, at least 1,500 cu. ft. of air per hour for new buildings, and at least 1,200 cu. ft. of air per hour for buildings constructed prior to the passage of the ordinance, which requirements the Illinois Chapter of the Society considers practical to obtain and desirable to require by legislation for motion picture show places.

Higher standards of ventilation than set forth as a minimum in the committee's report are urged wherever possible to obtain.

booth, and not less than 120 cubic feet of air per minute through a three-machine booth.

This requirement shall include a number of small metal screened openings (equipped with special dampers and automatic appliance with fusible link to automatically close tight in case of fire in the booth) on the sides of the booth near the bottom, aggregating 180 square inches for a one-machine booth, 210 square inches for a two-machine booth, and 240 square inches for a three-machine booth; and this requirement shall also include a metal or other fireproof flue, extending from the top or side at the top of the booth, and carried to a proper place of discharge outdoors. The ventilation should be augmented by mechanical or other means, so as to exhaust at least the quantity of air as herein stated.

The size of this special fireproof vent flue shall be not less than 96 square inches clear area for a one-machine booth, not less than 120 square inches clear area for a two-machine booth, and not less than 144 square inches clear area for a three-machine booth, and this special vent flue shall be provided with an adjustable damper, operated from the booth, and equipped with an automatic appliance and a fusible link to operate so as to open the damper wide automatically in case of fire in the booth. The machine booth ventilation shall be kept in operation at all times when the booth is in use.

SOME FACTS ABOUT VENTILATION.

Human beings or other animals in a confined space gradually consume the oxygen present and replace it with oxidation products, of which carbon dioxide is the most typical. Hence it was natural that attention should be fixed primarily upon these points, and it is still the popular belief that a crowded room is deficient in oxygen. Quantitative experiments soon showed, however, that these particular dangers were not of practical importance. The oxygen in the air must be reduced from 21 per cent to 15 per cent and the carbon dioxide increased from .04 per cent to 3 per cent before any marked physiological effect is manifest. These values are never remotely approached in what we consider an ordinary ill-ventilated room.

The next important theory that took possession of sanitarians depended on the assumption that in addition

to its more obvious constituents rebreathed air contained a mysterious organic emanation of poisonous nature, which was called "crowd poison" or "morbific matter." This theory rested primarily on the observed fact that crowded rooms have a foul, stale odor, and in some experiments which were later shown to be erroneous. It is certainly true that to anyone entering an ill-ventilated room from purer outside air, a marked and characteristic odor is apparent. There is no evidence that it exerts any harmful physiological effects and some evidence that it does not. Careful investigations made by physiologists of the highest standing have wholly failed to demonstrate any unfavorable effects from rebreathed air with all that it contains, provided only that the temperature be kept at a proper level. Benedict and Milner observed seventeen different subjects kept for periods varying from two hours to thirteen days in a small chamber with a capacity of 189 cubic feet in which the air was changed only slowly, while the temperature was kept down from the outside. The amount of carbon dioxide was usually over thirty-five parts (or eight to nine times the normal) and during the daytime when the subject was active, over 100 parts, and at one time reached 240 parts; and all the "morbific matter" or other deleterious entities which usually accompany carbon dioxide must have been present in corresponding proportion. Yet there was no discomfort whatever, and no detectable disturbance or normal physiological functioning as long as the chamber was kept cool. Dr. Leonard Hill has recently placed eight men in a closed chamber of 106 cubic feet capacity. At the end of half an hour the wet bulb temperature in the chamber had risen to 85 degrees F., the faces of the subjects were congested and they experienced great discomfort; but their feelings were at once relieved, without changing the air at all, by stirring it up and cooling their bodies by the motion of electric fans within the chamber.

Another point which has received more than its due share of popular attention is the possibility of the spread of disease bacteria in air. It is common for the "yellow sanitarian," if one may coin a term, to expose plates in a crowded room and show that a great many bacteria fall upon them, and then to call on us all to

share his horror. As a matter of fact, however, the bacteria in air are in overwhelming proportion, good, harmless saprophytic organisms. It is true that tubercle bacilli and some other pathogenic germs have occasionally been found in dust and dusty air, but rarely and in small numbers. While many disease germs are not immediately killed by drying, we may be sure from our knowledge of the general behavior of parasitic organisms outside the body that the percentage reduction in living virulent germs is rapid. From a bacteriological standpoint it is clear that air bacteria must be insignificant in their effects, compared from a quantitative standpoint, with the infection carried from person to person by many direct means.

It is, of course, true that in coughing, sneezing or loud speaking a spray of often richly infected droplets is discharged. The mouth spray is a local rain which drops quickly to the ground, not a general polution of the atmosphere. It could not be detected by any analytical standards, and could not be remedied by ventilation. It is a kind of direct contact rather than a problem of air pollution.

The really important factors which make for health or disease in the atmosphere are physical rather than chemical or bacteriological. From this standpoint the effect upon vitality is great, not only of the air we breathe, but of the air which surrounds our bodies.

The chief factors in air conditioning for the living machine, which in most cases far outweigh all others put together, are the temperature and humidity of the air. It is a curious instance of the way in which we neglect the obvious practical things and attend to the remote and theoretical ones, that for years more attention has been bestowed on the testing of air for carbon dioxide, which was supposed to indicate some mysterious danger, than on the actual concrete effects of overheating. Yet heat, and particularly heat combined with excessive humidity, is the one condition in air that has been proved beyond a doubt to be universally a cause of discomfort, inefficiency and disease. Fluegge and his pupils in Germany, and Haldane in England have shown that when the temperature rises to 80 degrees with moderate humidity or much above 70 degrees with

high humidity, depression, headache, dizziness and the other symptoms associated with badly ventilated rooms begin to manifest themselves. At 78 degrees with saturated air, Haldane found that the temperature of the body itself began to rise. The wonderful heat regulating mechanism which enables us to adjust ourselves to our environment had broken down and actual state of fever had set in. Overheating and excess of moisture is the very worst condition existing in the atmosphere and the very commonest.

Excessive humidity in the air works harm in two ways. At a temperature of above 70 degrees the body must rely largely on evaporation of the water of perspiration for maintaining its normal temperature.

If the temperature be below 68 degrees, on the other hand, an excess of moisture may exert deleterious effects of a precisely opposite kind. Under these conditions the body tends to cool too rapidly rather than too slowly, and the secretion of perspiration ceases. The moisture in the air no longer has any heating effect, but on the other hand, its presence raises the specific heat of the atmosphere, increases the amount of heat a given volume of air will take up from the body by conduction or convection, and thus directly exerts a cooling influence on the body.

On the other hand, an atmosphere which contains too little moisture is also undesirable. We have very little sound scientific knowledge about the physical effect of dry air and much that is written by extremists on the subject is without solid basis. Many persons can, however, testify to the discomfort they experience in steam heated rooms and it is probable, as Prof. Hough has stated, that "this is due to the too rapid evaporation of water from the skin and air passages. The skin thereby becomes dry and tends to chap, cutaneous nerves are irritated in an unpleasant manner, with more or less disturbance of affairs in the central nervous system.

Finally, dust particles in the air have a distinct and well established physiological significance, not as possible carriers of disease germs, but from their direct physical effect upon the tissues of the eye and nose and throat. The normal membranes of the body are usually able to defend themselves against invading microbes, but when

lacerated and injured by sharp dust particles, tubercle bacilli, which are latent in many lungs, and the germs of minor diseases and inflammations which are present in all normal throats, quickly gain the upper hand. The statistics of tuberculosis in various industries offer the clearest evidence of this, for, in the trades like grinding and granite cutting where the workers are exposed to large quantities of dust, the tuberculosis death rate may be four or five times the normal. Physicians have often testified, though without definite statistical evidence, to the relation between dust storms and diseases of the eye and naso-pharynx and to the beneficial effects of oiling the streets and preventing the dust from flying. There can be little doubt that dust in the air of a room may exercise a considerable harmful effect.

It might be thought from what has been said above that the determination of carbon dioxide could be entirely dispensed with, and some hygienists have taken that position. Personally I am not prepared to grant that under actual conditions of occupancy, no change of air is necessary, even if the temperature be kept down. It may be granted that in the laboratory rebreathed air has not been shown to be harmful when the effects of heat and humidity are eliminated. Under practical conditions, however, it is generally true that with stale air, carbon dioxide and heat and humidity and odors all increase progressively, though, of course, not all necessarily in the same ratio. The practical method of dealing with all these conditions is to change the air; and the change has an effect upon comfort which can not be measured by a theremometer.

Where there are no air currents the hot, moist, vitiated air from the body clings round us like an "aerial blanket," as Professor Sedgwick has named it, and each individual is surrounded by a zone of concentrated discomfort. The delightful sensation of walking or riding against a wind is largely due, perhaps, to the dispersion of this foul envelope, and Prof. Hill's experiment with the fan in his closed chamber shows how striking this effect may be. Under working conditions (except where electric fans are used in summer) it is the slow or rapid entrance of fresh air from without that breaks up this

blanket of foul air. Change of air is therefore practically necessary.

In regard to temperature there is one standard which can be fixed with confidence. It is, I think, quite certain that the temperature of the ordinary thermometer should never, under any circumstances, be permitted to pass 70 degrees F. The lower limit for persons with ordinary light clothing should probably be placed at 66 degrees F., for just below this point, as Sedwwick and Hough have emphasized, there is a likelihood of gradual and unnoticed chilling of a dangerous kind.

In regard to humidity it is not possible to speak with the same certainty in the light of present knowledge. If the temperature be maintained between 66 and 70 degrees a relative humidity of about 70 per cent may be considered as a maximum beyond which it is undesirable to go. A lower limit may perhaps be tentatively set at 60 per cent.

A standard for permissible dustiness is quite beyond the present range of our knowledge. Dr. Soper in the studies made in connection with the New York subway found 52 mg. of dust per 1,000 cubic feet of air as an average for the street air of New York. If more than 50 mg. of dust are found per 1,000 cubic feet of air, the condition is worse than that which obtains in the streets of New York, and there is no reason why an enclosed room should not be kept freer from dust than the air of a city street.

The standard for carbon dioxide should be made a fairly liberal one in view of the fact that it is to be used not as an index of any mysterious poison, but simply as a measure of air change. Taking the normal for city air at .04 per cent, it seems reasonable to allow an increase to .12 per cent or three times the normal. This is the standard suggested in recent English reports for several classes of factories and established for the garment shops of New York by the joint board of sanitary control in the cloak, suit and skirt industry. It means an allowance of 700 cubic feet of air per person per hour, about one-fourth of what is required by ordinary mechanical standards of ventilation, so that it certainly cannot be considered excessive.

There is one point which may, perhaps, be em-

phasized in closing, although it is not a question of standards. That is the importance or "perflation," or the complete flushing out of a room at intervals with vigorous drafts of fresh, cool air. The gradual air change accomplished by ventilation is not nearly as effective from the physiological standpoint as the opening of windows for five minutes. A gale of wind not only brings general coolness, but it breaks up the aerial blanket and gives a new mental tone to mind and body which can be attained in no other way.

VENTILATING FANS.

Fans for theater ventilation may be divided into two general classes: those used for exhausting the interior (known as "exhausters") and the class commonly met with in stores and offices known as desk and ceiling fans, whose duty is merely to circulate the the same air around the room, over and over again. The first class, or the "exhausters" insures a positive supply of fresh air at all times since the vacuum produced by them causes fresh air to enter the theater from out of doors, both through the open doors and the cracks and crevices in the building. In general, both types are necessary for the comfort of the audience, especially during hot weather, for the exhauster rids the theater of objectional odors, and the fan cools by evaporating the perspiration of the body.

DESK FANS (WALL FANS).

As a general rule, the deck fans are mounted on brackets above the heads of the audience, and are arranged so that the air stream is directed down and towards the curtain (in case the screen is located at the rear end of the room). They should be controlled by means of a switch or speed regulator located in the opening booth so that the operator can slow them down or cut them out during a song or vaudeville act.

While the fans do not require much attention, they should be examined occasionally to determine the condition of the brushes and commutaters, and to supply fresh, clean oil. All makes of fans are of the "self-oiling" type, but the reservoirs should be cleaned out and refilled at least once every month.

Never allow the brushes to spark, either readjust them, or supply new ones, should they be worn too short. Sparking brushes soon destroy the commutator and cause costly repairs. If the brushes are not the cause of the sparking examine the commutator, remove the dirt, and smooth with very fine sand paper (not emery). At the end and beginning of the season clean the fans thoroughly by washing the armature in gasoline, a process that will remove the destructive lubricating oil from the insulation.

The fan circuit should be entirely independent of the lighting and projector circuit except in very small houses.

EXHAUSTERS.

It is usual to install exhaust fans in a circular opening at the rear end of the hall, so that the air is drawn from the doors and over the heads of the audience. Like the wall fans, the exhauster should be provided with an independent circuit, and speed regulating device, the latter to be installed in the operator's booth. The regulation of the exhauster is of much more importance than that of the wall fans since it draws a much greater current. During periods of light attendance, the fan speed may be reduced, thus obtaining a considerably smaller power bill.

A rough table, which actually is nothing but a table of comparative values of capacity and outputs, follows. The outputs and powers vary considerably among different makers for the same diameter of fan, since the blading and speeds differ. A fan is always listed according to its diameter, a factor that has really a small amount to do with the capacity:

Diameter	Power in kilowatts	Revs. per minute	Cu. ft. per hour of air removed
12	0.05	1000	62,000
16	0.07	900	70,000
18	0.10	750	110,000
24	0.20	600	300,000
30	0.35	500	400,000
36	0.45	450	700,000
42	0.550	360	820,000
48	0.650	300	1,000,000

CHAPTER VIII.

COLORED PICTURES—STEREOSCOPIC PICTURES—TALKING PICTURES—PRINCIPAL METHODS OF COLORING IN BRIEF.

One of the earliest and most commonly adopted methods of coloring both still and moving pictures is by the means of a brush and water colors, the various colors being applied by hand. That this is a tedious process, and that it requires considerable skill requires no further comment, the fact that millions of dollars have been spent in the attempt to produce the colors mechanically or chemically is sufficient proof.

While it is not particularly an expensive matter to hand color a few lantern slides or photographs, the expense is nearly prohibitive in the case of motion picture films where the number of pictures run into the thousands, and where it is necessary to work correctly within 1-500 of an inch.

As an example of the labor required to hand color a reel of 1,000 feet of film, we will state that this single reel contains 16,000 pictures, each picture being not much larger than a postage stamp. To apply three colors within the limits of 1x¾ inches by a brush requires skill and patience of no mean order, and when one realizes that each print produced must go through the same process, since it is impossible to print colors from a colored negative, we can easily see why the hand colored films were almost withdrawn from the market.

Hand coloring requires great accuracy, if it is to be acceptable when projected, for when the picture is magnified from 200 to 240 times its original dimensions, the smallest error in applying the color is made painfully apparent. An error of 1-64 of an inch on the picture will bring the color four inches away from where it belongs on the screen.

To produce colored pictures at a reduced cost, the film manufacturers soon devised a semi-automatic method of coloring by means of stencils, a system that is much used today. The stencils are cut from heavy paper to the outlines of the figures on the film, a separate stencil being used for each color on the separate pictures. There being three colors, each picture requires three stencils, and as the figures are in different positions on each of the small photographs, there are nearly as many *sets* of stencils as there are photographs on the film. The method of cutting and applying the stencils will be described further on in this section.

Processes by which the natural colors could be produced directly upon the film by photographic means were proposed early in the history of the motion picture, but few of these were found practicable. In all of these inventions, the natural colors of the object photographed were separated into their primary colors, and each color was recorded either on a separate film or upon a separate photograph on the same film. The Kinemacolor system is an example of the latter process.

It was soon found that it was impracticable to use all of the seven primary colors upon a single film because of additional film area required by so many separate photographs, consequently the number of colors were reduced to two or three, an approximation that was very close to the results obtained by use of the entire spectrum. In nearly every case the colors were separated by passing the lens rays through colored glasses, blue, yellow and red rays being obtained by the use of blue, yellow and red glasses. After passing the rays through the colored glasses, commonly called "Filters," each color was projected on the film as a separate picture.

After development, the pictures obtained by this process greatly resembled the ordinary black and white film, as there was no color visible on the negative, but when the prints were passed through a projector, especially equipped with colored filters, the pictures appeared in their natural tints on the screen. By means of special shutters, etc., the images containing the red portions of the objects were passed through the red filters; the light

from the images taken behind the blue filter in the camera was passed through the blue filter on the projector, and so on, each color appearing in its proper place on the screen. Each color on the object was photographed separately and then projected separately through a suitably colored filter.

Two different methods have been adopted for projecting the separate photographs upon the screen, one being known as "Simultaneous Projection" and the other as "Alternate Projection." The Kinemacolor is a machine using alternate projection.

In simultaneous projection all of the colors on the film are projected at one time, the tints differing slightly from the filter colors being produced by the overlapping portions of the various colored images. If blue, yellow and red filters were used in the projector, a green tint would be obtained by the edges of the yellow photograph overlapping the edges of the blue image. A brown would be obtained by the overlapping of the yellow and red, and so on. As can be imagined, quite accurate adjustment was required in order to have each picture register at exactly the right point on the screen.

Another method, the alternate, is the projection of each picture alternately, or one at a time upon the screen. If the separate pictures follow one another rapidly, the effect is nearly the same as that obtained by simultaneous projection. This is based upon the same fundamental principle as that of the motion picture; i. e., persistence of vision. If a green image is rapidly succeeded by a red image, the eye still retains the impression of the green image at the time that the red image appears on the screen, thus obtaining a combined impression of the two colors. If certain portions of both the red and green images occupy the same place on the screen, the effect is exactly the same as that obtained by overlapping in simultaneous projection. This method requires two and one-third times the speed used either with the black and white pictures or with simultaneous projection.

PATHE'S STENCIL COLORING METHOD.

The method adopted by Pathe Freres, Paris, is an example of experience and ingenuity in coloring motion

picture films. The method is very nearly automatic, and that part of the process requiring hand labor can easily be performed by comparatively cheap labor.

In viewing a scene, the eye not only notes the outlines of the objects but notes the colors and shading as well, the total mental effect being composed of simultaneous impressions of color and form. It is evident, therefore, that the common black and white pictures lack a vital element in creating what otherwise would be a perfect illusion. Not only is the illusion of the picture affected by a lack of color, but the effect on the eyes of the spectators is made a matter of importance, because of the eyestrain occasioned by the glaring contrasts of the black and white shadows and high lights.

While there are now many makes of colored pictures on the market, the greater proportion of the pictures shown are still of the black and white variety, a condition caused principally by the mechanical difficulties encountered in producing a film containing more than one color. Cost, difficulty in projection, or inefficiency are factors that have eliminated a host of inventions along this line. It should be understood in this connection that we are referring to pictures containing two or more distinct colors which by their combination form a number of intermediate shades, and *not* to the single colored "tinted" or "monochrome" films described in an early chapter.

COMPOSITION OF SIGHT.

In order to fully understand the theory of colored pictures it should be noted that the sunlight (white light) is composed of seven distinct colors—violet, indigo, blue, green, yellow, orange and red. Together, these colors can be resolved into the white light from which they were separated. These seven colors are known as the "colors of the spectrum," or more commonly as the "colors of the rainbow," since they appear distinctly in that phenomena.

Color, as we know it, is therefore the result of breaking up a beam of white light in such a way that one or more of the primary colors (any number less

than seven) are thrown out of the main beam and transmitted to the eye. In general there are three ways of breaking up the white light beam; by reflection, refraction, and by transmission, all three of the methods being practised in nature, and at least two of them in motion picture photography.

SEPARATION BY REFLECTION.

When looking at an object upon which a beam of white light is playing, a portion of the light is absorbed by the surface, and the balance is reflected to the eye. The nature of the reflected light depends upon the character of the surface, some substances absorb a particular part of the spectrum and reflect the rest, causing of course, an impression of color. The colors seen by the eye are the colors reflected from the surface. If, for example, an object appears red, we know that all of the spectrum with the exception of the red has been absorbed. Should two or more colors be reflected, the result will be an intermediate shade caused by the combination of the reflected colors.

SEPARATION BY REFRACTION.

When a beam of white light strikes a transparent body at an angle with its surface, the beam is broken up into its seven primary colors, forming a band of colors called the "spectrum." In nature the spectrum is seen in the rainbow, the light in this case being broken up by sun rays striking the surfaces of the raindrops from which the various colors are refracted to the eye. In practice, the spectrum is usually obtained by means of a triangular glass prism on which a slanting ray of white light is allowed to fall.

Color separation by the prism or raindrop is caused by the difference in velocity or wave length of the different colored rays, the higher velocity rays being thrown at one end of the spectrum band, and the lower velocity rays at the other. Since the two velocity extremes are found in the violet and red rays, it is evident that they will be found at opposite ends of the spectrum, with

the remaining seven colors arranged in the order of their velocities.

In color photography, the method of refraction has been but little used up to the present time, but since it is a simple means of separating and recording every possible color contained in white light, it will undoubtedly come into use in the future.

COLOR SEPARATION BY TRANSMISSION.

When light is passed through transparent bodies, such as sheets of glass, it is seldom that the transmitted light (the light passed through the sheet) is of the same color as the original beam. Different chemical compositions transmit varying proportions of the primary colors, the glasses reflecting some of the rays and transmitting others. By varying the composition of the glass it is possible to stop the transmission of any desired ray or rays and to reflect the balance. This explains the difference in color obtained by viewing a glass or fluid by reflected light, and then by holding the glass between the eyes and light and obtaining a view of the transmitted beam. Often a glass will appear greenish blue by a reflected beam, and prove a ruby red by transmitted light. There are many fluids that exhibit the properties of the glass just mentioned, a striking case being that of a saturated solution of sulphate of quinine.

The film to be colored is mounted between two reels in a chamber, the top of which is part of the working table and contains a ground-glass window on to which is projected, by the light of a Nernst lamp, an enlarged image of the picture being dealt with at that moment. The operator decides which portions of this picture are to be dyed, say red, and then, round these portions, she guides a stylus carried by a pantograph link work which is so proportioned that the motion of the tracing stylus is reduced in exactly the same ratio as the film picture is magnified on the ground-glass screen. The reproducing point of the pantograph consists of a fine needle which is vibrated up and down by the ingenious mechanism roughly sketched in Fig. 59. The winged plate *SS*, carried by a vertical spindle, is rotated by the attraction of *MM* when the latter are excited. Hitherto, the tiny connecting rod *C* (which has ball joints at each end), has been in an oblique position; but the

rotation of *SS* forces *C*, to approach a vertical position thus thrusting down the block *B*, and hence, through a sleeve coupling, the stencil cutting-needle *N*. The deflection of *S* automatically breaks the field circuit of *MM* and, the moving parts being spring controlled, there is secured a rapid vibration of *N*, which is maintained so long as a master contact is closed by the tracing style being held down against the glass-tracing screen.

The whole of the mechanism outlined in Fig. 59 is carried by one of the pantograph bars so that the arrangements made to vibrate *N* in no way effect the movement of the latter as the reproducing style of the pantograph. A blank film is clamped beneath *N* and, on proceeding as above, there is punctured on the stencil film a series of very closely adjacent holes which mark out the actual size and position of those portions of the positive film which the operator has selected for red coloration. This being done, the positive and the stencil films are moved forward one picture-pitch by a simple wheel and ratchet gear and the operation is repeated.

Finally, the detachable portions of the stencil are cleared away by aid of a pointed style and the finished stencils (and the pieces removed), present the appearance shown in Fig. 60. The beautifully sharp edges of the stencils are remarkable.

One stencil is cut for each color to be applied to each picture so that, for a three-color film 48,000 and for a seven-color film 112,000 stencils have to be cut for each 1,000 feet of positive film.

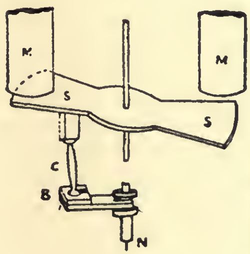
To dye films for exhibition is a simple matter once the stencils have been cut. The film is pressed in close contact with the stencil and is passed beneath an automatically-fed dye-band. Thick aniline dyes are used and the film can be passed direct on to the receiving spool without preliminary drying. The whole dyeing machine is driven by a 1/3-1/4 h.p. electric motor and the film is passed through it from three to seven times (according to the number of colors selected), the appropriate dye and stencil being used in each case. Usually about 100 films can be made from one set of stencils before the latter begin to show signs of wear.

This, briefly, is the process by which Pathe-color

films are prepared and we have described it in some detail since it is as ingenious as it is successful.

DIFFICULTIES OF COLOR PHOTOGRAPHY

Even with the photographic system in which each color is recorded by a separate picture, the production of color is attended with great trouble and expense, so great, in fact, that there are at the present time but few systems that have proven a commercial success. Peculiar mechanical and photographic factors as well as lighting and physiological difficulties, not understood by



Figs. 59 and 60—Pathe Stencil Cutter.

the average experimenter, have reduced an innumerable host of color patents to three or four indifferently working machines.

The very fact that the use of three colors requires three times the length of film used in projecting black and white pictures suggests that the expense of film is greatly increased and that the machine is required to operate at three times the speed to project the same subject, thereby increasing the wear and tear on the projector. With two colors, one third less film is required than with three colors, but the amount of film

is still excessive, and the projection is not as effective as it might be owing to the loss of an intermediate primary color.

Attempts to reduce the length of film by photographing all three colors directly upon a single picture have been made from the first, but while fairly successful with still life photography this method has proved an utter failure in motion picture work. The great magnification of the projection lens made the use of starch granules and prismatic oilings useless.

Because of the distortion in the light rays caused by the filter glasses, and the impossiblity of obtaining perfect mechanical adjustment in the camera and projector it has been very difficult to exactly superimpose the two colored images upon one another on the screen. This error creates a "fringe" of color around the most promment objects very similar in effect to that noticed in cheap color printing where the colors are "out of register" and overlap one another. Fringing is one of the most apparent and disagreeable failings of the color photographic process for the continual shifting and color changes in the outlines has the combined effect of shutter fluttter and rain. In addition a heavily fringed picture has the appearance of being out of focus.

Two color pictures in which only red and blue-green are used can never, of course, be true to nature in regard to the coloring. True blue, one of the commonest of the primary colors in nature, is entirely lacking, with the result that grass and sky are shown in practically the same tint. Purple with two color projection is converted into a light green while yellow approaches orange, the latter being the product of the combination of the red with the yellow component of the green. One of the intermediate colors, brown, is rendered beautifully, however, and in almost any desired shade.

Another factor regulating the faithfulness of color in any system is that of the light under which the pictures are taken. An intense light dims the brilliancy of the color because of the extent of the high lights and the relative density of the shadows. Colors that appear rich and full in a subdued and diffused light become thin and flat under a brilliant sun.

As explained in a preceding chapter, the ordinary speed for black and white projection is at the rate of sixteen pictures per second. At this speed the eye is unable to distinguish the individual pictures and the motion is therefore apparently continuous. Unfortunately this is not rapid enough for two color pictures shown in alternate projection, for at the rate of sixteen per second the eye is able to distinguish the successive flashes of red and blue light. As a result, the strain on the machine is again increased, for the films are not only twice as long but must be run at a speed of two and one-third times that of the black and white picture. Even at this speed the independent colors may be distinguished by waving the hand between the eyes and the screen, an action that will result in a rapid red and green flicker on the edge of the hand.

Two color projection is limited to comparatively slow moving objects for the reason that the successive positions of such objects are alternately registered on the green and red pictures. The projection of the moving objects results in a disagreeable flicker, the entire surface of the figure being alternately green and red as it passes across the screen. A galloping horse for example will be shown with eight legs, four red and four green.

Still another difficulty is encountered in direct color photography with filters, that is the impossibility of photographing through a red glass with the ordinary photographic film. Every photographic amateur knows that even the most rapid of films are safe when exposed to the rays of a red dark-room lamp, and consequently can imagine the length of time that would be required to obtain a picture under these conditions.

To take motion pictures through a red filter glass requires a film that is equally sensitive to red, blue and green light. The solution of this problem was one due to chemistry, that is, the problem depended for its solution upon an emulsion of an entirely different character from that used in everyday photographic processes, a difficulty that was seemingly as near the impossible as that of obtaining correct projection. This, however, was finally mastered but at the expense of an increase of trouble in the manufacture of both the film stock and the finished picture, for now the film was sensitive to any

form of light and required handling in an absolutely dark room, without even the aid of a ruby lamp. A weak picture taken under the red lamp meant a preponderance of red on the screen.

A film of this character, known as a "panchromatic" film, is generally obtained by treating an ordinary emulsion with a special sensitizing solution, such as pinacyanol or ethyl-violet. The exact proportions of such a solution and the details of its application is a trade secret carefully suppressed by the makers of the film. It is sufficient to mention that the additional handling, the short actinic life of the panchromatic films, and the difficulty experienced in handling it in total darkness all contribute to a great increase in the cost of production.

FRIESE-GREEN PROCESS.

The Friese-Green process, of which little is yet known commercially, is one of the oldest examples of color motion picture photography. Two lenses are used, both in the camera and the projector, which give two screen images of two colors each, the negative being of the three-color type—red, green and blue. The lenses act through filters giving a black and white negative which reproduces the original colors by being projected through corresponding filters in the projector. The projection speed is the same as with the ordinary black and white films, sixteen per second.

Two separate rolls of film are used in the camera, each roll being used with independent lenses, filters and shift mechanism, the duplicate parts being operated by a single crank. The two systems form practically separate cameras as far as the operation is concerned.

The two shutters open the lenses alternately, producing pictures alternately on the two films, so that a green light in one camera is succeeded by a blue light in the other. A further turn throws a red image on the first film and then a green light on the second. After this part of the revolution a blue light is thrown on the first film and a red image on the second. After the above reversals the cycle is repeated in the same order over and over again. The filter is in the the form of a continuous band that moves in unison with the shutter so that the three colors are brought before the films at the required moment.

Like the camera, the projector consists of two independent lenses and shift mechanisms driven by one crank with a three-color band filter. The projector shutters and filter colors pass through the light beam so that the images on the two films arrive in the same sequence on the screen as they did in the camera, except that the colors are allowed to overlap. That is, the image from the second projector is thrown on the screen before the image from the first is cut off. In this way many intermediate tints are possible, and as the colors merge one into the other, the danger of color flicker is reduced. Another apparent advantage of this system is the fact that there is always light on the screen and consequently a maximum of illumination.

KINEMACOLOR (URBAN-SMITH).

The Kinemacolor process, the best known example of true color photography, employs two colors which are alternately projected. The underlying principles of this type of machine were discussed in an earlier portion of this chapter—where it will be remembered that the color-effects depend entirely upon the persistence of vision.

Two colors, red and blue-green, supplied by two filters, supply the entire range of effects, and without overlapping, as in the Friese-Green system. Whatever intermediate tints are produced are caused by overlapping the pictures mentally. The film itself is black and white, similar in appearance to an ordinary film, and is projected at about two and one-third times the speed of the black and white film. As a result of this speed the projectors are always driven by a motor, for the work is far beyond the capabilities of the ordinary operator.

A panchromatic film is exposed by a double shutter camera that throws the light from red and green filters alternately. The pictures thus produced extend down the center of the film in a manner similar to that of an ordinary film, except that the pictures are alternately taken through red and green filters. To distinguish the green pictures from the red, a small green dot or dash is stamped on the margin opposite each green picture, so that in case of a break the film may be patched in the correct relation.

In projecting this film the beam of light passing through the successive pictures is alternately colored

red and green by a shutter that also acts as a filter. The green blade comes before the beam when a green picture is in the aperture, and the red blade enters when a red picture is in the aperture. As the pictures are on a single strip of standard film, it is necessary to use only a single lens, and for this reason it is possible to run an ordinary black-white film in the same machine by cutting down the speed and by substituting an ordinary shutter.

Kinemacalor films require much more light than the ordinary film because of the intervention of the colored shutter.

The shutter is a circular disc with two color windows of gelatine, one red and one green. The ordinary opaque shutter used for blacks and whites is left on the shaft with the color shutter and serves to shut off the light when the open spaces between the color sectors pass the lens. A single thickness of gelatine is used in each sector with a second sector thickness on the green that occupies about one-half the space of this sector. The purpose of this additional thickness on the green sector is to regulate the relative proportions of the red and green light. When the volumes of the red and green light are correctly proportioned, a perfectly white light will be produced when the shutter is rotated without film in the aperture as red and green are complementary colors.

GAUMONT'S CHRONOCHROME.

Gaumont, the French film producer, has recently devised a direct color photographic system that is said to be greatly in advance of any similar device on the market. From the reports of European technical experts, the inventor has completely overcome the loss of color register and illumination that have been the despair of other experimenters. Because of the late development of the camera and projector it is impossible to describe the mechanical features of either the camera or the projector.

The technical expert of the London *Bioscope* in a recent issue of that publication writes as follows of the chrono-chrome pictures:

Briefly it may be said that the results of chronochrome are secured by the simultaneous photographing and ultimate projection of three photographs containing the primary color values in the field before the lens. In

previous experiments in the same direction it has been found impossible to accurately superimpose the three color value pictures, each one, of course, projected through its respective color filter upon the screen. Messrs. Gaumont have, however, completely overcome the difficulty, and as proof of the simplicity and ease with which the superimposition may be performed, it is only necessary to record the fact that in one picture which was unintentionally thrown upon the screen with the colors projected out of register, they were almost immediately and accurately superimposed.

As in the color system under review, there is always on the screen (with, of course, the exception of the intervals during the interception of the shutter) a multi-colored picture, eye fatigue is conspicuous by its absence, as no persistence of vision is necessary for the blending of one color into another, the actual natural colors themselves being displayed. The color effects are, therefore, not illusionary, but real.

At the demonstration we were afforded an opportunity of judging the results of a wide range of subjects: Flower studies, farm yard scene, panoramic scenes in the Balearic Isles, butterflies, harvesting and others. In all there was nothing but admiration expressed by the large audience, the flower and butterfly series perhaps calling for most admiration. Certainly it can be said that never before have the myriads of nature's tints been so faithfully recorded. The bloom on the begonias and the remarkable iridescent tints on some of the butterflies were beautiful and beyond anything we had previously thought it possible to obtain by photographic means, while proof that there was no limitation to the process was afforded upon the projection of the harvesting scenes and views of the Riviera—faithful reproductions of nature.

One test for color process is white and the remarkable purity of this was shown in the last picture, introducing the tricolor and Union Jack, both of which, fluttering in the breeze, stood but in apparent relief as if no photographic medium were used.

PRODUCTION OF COLOR IN STILL PICTURES.

In my opinion, many of the color photographic processes that have proved successful in "still" pictures could be, with certain modifications, applied to motion picture

films, especially as the majority of these processes exhibit color on transparent positive prints. A few of these possibilities will be outlined in the following paragraphs.

STARCH GRANULE PHOTOGRAPHY.

An early method of producing colors on dry plate transparencies involved the use of two glass plates, one of which was a clear transparent cover plate and the other, a panchromatically sensitized dry plate. Over the cover plate was spread an intimate mixture of minute starch particles which were fastened to the plate by a binder film of collodion or gelatine. One-third of the starch granules were colored blue, one-third were colored red, and the remainder yellow, and were very thoroughly mixed before applying to the plate so that a red particle, for instance, would be immediately adjacent to one blue and one yellow.

After the starch plate was thoroughly dried, it was placed upon, and face to face with the dry plate, and then inserted into the camera and exposed in the ordinary way. After exposure, the starched cover plate was removed and the dry plate developed in a dark room. The plate thus produced was in itself perfectly colorless, but when the cover plate was replaced in exactly its original position and the two plates were held up to the light, all of the objects were shown in their true colors. This result is due to the fact that the colored starch particles acted as minute filters both when the picture was taken and when exhibited, the red particles transmitting only the red rays, the blue granules the blue rays, and so on, forming a typical three color picture. The great difficulty in this system is the great care needed in exactly superimposing the granules in their original position after the development.

In motion pictures this difficulty would be increased owing to the necessity of a double film that would be nearly inflexible and which would spread the surfaces every time that they passed over a sprocket or idler.

COLORED RULING.

A system very similar to the starch granules is that of the three color ruled cover plate. The starch granules in this case are supplanted by very fine colored lines that are ruled on the cover plate, the lines being placed in

very close proximity to one another. The lines are successively, red, yellow and blue and are placed in direct contact with the sensitized emulsion of the dry plate before exposure and after development. The difficulties would be the same with this system as with the starched plates, i.e., accurate registration, and the necessity of two plates or films.

TRIPLE EMULSION.

A system has been proposed that involves a film or plate with a triple emulsion consisting of three chemically different sensitizers arranged in superimposed layers. One layer would record only the red, the second all of the blue rays, and the third only the yellow rays. After development, three staining baths would stain the appropriate layers with an individual color, producing a directly colored film similar to those produced by hand painting. So far, the proper chemical compounds have not been discovered that would make this system even an approximate success, but it is possible that some research in this line would solve the problem and eliminate the evils of long films, excessive speeds and the inaccuracy of color filters.

COLORS BY REFRACTION (SPECTROSCOPIC PICTURES).

Pictures produced by refraction, or by a prism produced spectrum possess many advantages over those produced by other means:

1. All of the seven primary colors are present making any tint or shade possible.
2. A single picture could produce all of the colors, making long films and a multiplicity of pictures unnecessary.
3. Only a single lens would be required.
4. There would be no filters required, and therefore the registration would be perfect.

A method still in its experimental stages, but which seems to possess desirable properties is described in the following translation of an article taken from *"La Nature."* It should be understood that at the present time this has only been tried with still pictures, and that certain modifications would be necessary when applied to motion pictures.

The theory of the process is a simple one. It consists in producing by optical means a surface composed

of hundreds of complete but very narrow spectra, lying next to one another, the spectra being so close together as to render the individual colors indistinguishable to the unaided eye, so that the surface appears to be white. The photographic positive is used as a mask to block out or weaken those colors which are not wanted, the remainder combining to form the picture.

The surface, composed of those contiguous narrow spectra, is produced by allowing white light to fall upon a fine line screen, of which the opaque lines are three times as wide as the clear interspaces, and forming an

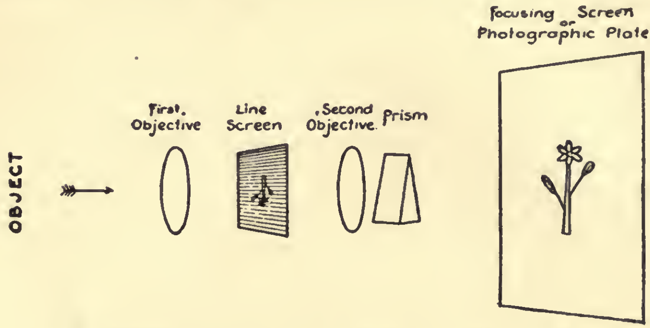


Fig. 61—Diagrammatic View of the Elements of the Color Machine.

image on this screen by means of a lens with a prism just in front of it. The prism spreads each white line into a complete spectrum, and is so calculated that the spectra lie next each other on the focusing screen without interspace. If instead of white light falling upon the line screen we allow colored light to fall upon it, only those spectrum colors of which the line in question is composed appear on the focusing screen, the colors which are wholly or partially missing from the spectrum of white light being represented by spaces wholly or partially dark.

In taking the photograph the image of the colored object is projected by means of any ordinary objective lens on to the line screen, the image of which is in turn projected by the second lens with the prism in front of it on to the photographic plate placed in the position of the focusing screen. (Fig. 61 shows diagrammatically the general optical arrangement.) The plate must be

approximately equally sensitive to all colors, so that the resulting negative is completely darkened when acted upon by any color in its full intensity, and partially darkened where the incident color is weakened. A lantern slide positive from this negative will, of course, show the reverse effect, being completely transparent where the color has acted with full intensity, of partial transparency where the color has acted less strongly, and opaque where the colors were missing, i. e., in those parts coincident in position with the spectrum colors of white light that were not present in the object photographed. When, therefore, this positive is placed in the exact position of the negative, and white light is projected through the apparatus, it acts as the desired mask to block out those

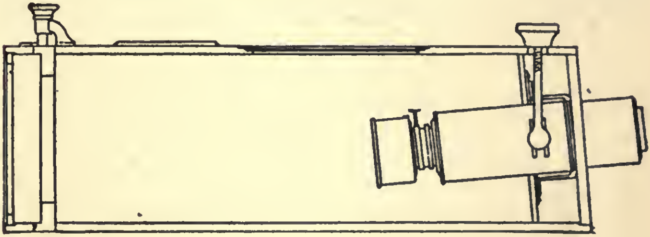


Fig. 62—Section Through Camera.

colors that are not wanted, and the picture is reproduced in the original colors.

Like so many other scientific problems, however, while the theory was simple, in practice, difficulties in the way of the construction of the necessary apparatus (Figs. 62 and 63, arose at every turn, and matters were further complicated by the necessity of keeping the camera within portable limits. To indicate one of the main sources of difficulty, an ordinary glass prism produces a spectrum widely extended in the violet and blue region and crowded up at the yellow and red end, an effect very detrimental to the proper rendering of the latter colors. This was overcome by the use of a compound prism specially computed to give a spectrum in which the colors are evenly distributed, as in a grating spectrum. The introduction, however, of a thick prism of this kind introduced aberrations of all kinds, both in the images of the object and of the spectra, which had to be successively

overcome. It was, for example, found necessary to place the line screen (which has 372 lines per inch) at a slant to bring the spectra all over the field sharply into focus; a cylindrical lens is used in front of the prism to correct for astigmatism; the front of the camera is placed at the proper angle to prevent wedge distortion; a narrow prism behind the first objective brings the object sharply

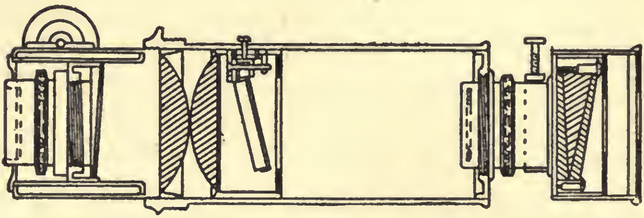


Fig. 63—Lenses and Prisms.

into focus, and so on. The objectives used in the camera are two 75 millimeters, Zeiss, micro-planars. A field lens is interposed between the first objective and the line screen to direct the light toward the second objective. The whole optical system can be slightly rotated by means of a milled head on the left hand side of the camera in front; at the back is another milled head securing slight lateral movement, and a lever above the viewing screen permits of a slight backward or forward movement of one-half millimeter. These three movements are necessary to enable the lantern plate to be brought to the exact position of the negative, but correct registration is easily secured in a few seconds—the readings can moreover be noted on the positive.

Besides the method of viewing the picture on the focusing screen of the camera which requires a strong artificial light source, the pictures may also be viewed direct on the line screen by means of a magnifying eye piece for which purpose ordinary daylight or a weak illuminate suffices. This method in practise does not however yield quite such good results. The pictures may be projected up to four feet in diameter on a lantern screen.

Until the advent of a really good bleaching out paper there is no possibility of recording the photograph in colors on paper.

STEREOSCOPIC PICTURES.

As the ordinary black and white picture camera is provided with but a single lens, the pictures are unnatural to a person who views the same objects with both eyes for the reason that the two eyes can embrace a greater angle and therefore can see "farther around the object" than the lens. A picture taken with a single lens is "flat," that is, the objects do not stand out in prominent relief against a flat and inconspicuous background.

To obtain an impression similar to that given by eyes it would be necessary to provide two pictures that have been taken from two different points lying in a line drawn perpendicular to the line of sight, corresponding to the separation of the eyes. If these photographs were now viewed independently, one with each eye, in their proper relation, the objects would appear in relief as they really do in nature. To obtain a perfect impression it would be necessary to place an opaque partition between the eyes so that the sight of each eye would be confined to its proper picture.

With still pictures, the stereoscopic effect is obtained with a very familiar piece of apparatus; at one time existing in nearly every home, called the "Wheatstone Stereoscope." This consisted of a wooden frame on which were mounted two rectangular lenses, contained usually in a wooden hood or shield that fitted close to the forehead. Opposite to the lenses was a sliding rack that held a double photograph (two pictures on one card), which could be viewed through the two lenses. On looking through the lenses at the photos they appeared as one picture, but unlike the originals, they appeared to stand out in bold relief.

These stereoscopic pictures were very nearly alike, but had in reality been taken by a double lens camera in which the lenses were placed in the same relative positions as that of the eyes. The result of this arrangement was that the right hand picture gave more of the right hand sides of the object than the left hand, and vice versa. As the right eye saw only the right hand picture, and the left eye the left hand picture, the natural conditions were reproduced and therefore prominent relief was obtained.

Another method afterwards obtained the same re-

sult with a single picture printed in two colors, red and green. The green picture was printed from the right hand lens of a double lens camera, and the red picture with the left hand lens, so that if the two colors were viewed, one with each eye, a stereoscopic effect would be obtained similar to that of the two photographs in the "Wheatstone" instrument. Viewing the picture directly with both eyes without a suitable instrument for separating the colors revealed a mass of muddled color blotches having only the slightest resemblence to the outlines of the picture that they represented.

A pair of spectacles having one green glass and one red were provided, the colored glasses acting as light filters in separating the different colored rays. With the green glass over the right eye and the red glass over the left, the green and red pictures were only visible to the right and left eyes respectively. As these pictures were taken with a double lens camera, the right eye saw that part of the object seen by the right lens, and the left eye saw the impression of the left hand lens,—giving a stereoscopic effect. Red and green being complimentary colors, the total impression was that of a black and white picture.

Since the ordinary two color motion pictures are often taken with a double lens camera it is sometimes possible to obtain stereoscopic effects with colored glasses as one lens only takes greens and the other, reds. This is most prominent with the use of alternate projection.

Up to the present time stereoscopic pictures in black and white have not been successful and even with colored pictures the effects have not been particularly prominent to the naked eye. To obtain stereoptical relief would naturally involve the use of either double films or superimposed two color photographs with their attendent evils. The trouble of providing each person in the audience with special viewing glasses would alone prohibit such films, neglecting altogether the cost of producing the films.

TALKING PICTURES.

Picture projectors interconnected with a phonograph in such a way that the action and sound are reproduced simultaneously have been proposed from the earliest days of the motion picture industry. Unfortunately the difficulties met with in the practical application of this

principle have proved unsurmountable except in one or two cases.

In theory, the simplest way to make such pictures would be to place the recording phonograph and the motion picture camera as conveniently as possible to view the scene and hear the sounds, and run both of them at a constant speed, taking the two records simultaneously. Then for rendering the records for entertainment, it is necessary only to start the two records, the reproducing phonograph and the positive picture film in the projecting machine, simultaneously, and to run them at their proper and constant speed.

This is not so easy as it appears at first. In making the records, the camera and the recording phonograph would interfere with each other; and further, the requirement of uniform speed is one which is entirely theoretical; we do not have constant speed in general practice, and cannot attempt to attain it for theater projection work.

In the song and dance, or vaudeville sketch, which seems to be the most popular form for "talking pictures," the movement of the speaker or singer or dancer for the effect in the picture would act to given a very uneven phonographic record.

To obtain a perfect picture of this class it is absolutely necessary to obtain perfect "synchronism" in the motion and sound, or in other words, to have the motion and sound exactly "in step." The attainment of this requisite constitutes one of the greatest difficulties in making talking pictures. The film and the phonograph must start and keep together throughout the length of the act.

Exact synchronism and speed is made doubly difficult from the fact that the sound must proceed from the stage or the curtain at the front of the house while the projector must of necessity be located at the rear. This great distance between the mechanisms of the projector and phonograph makes a positive mechanical connection impossible, and therefore reliance must be placed on electrical or manual regulation, two rather erratic methods of control.

Another factor that enters the problem is that of film breakage, for even should the new film and phono-

graph record be in perfect synchronism, the absence of a few pictures taken in patching the film break will throw the machines out of step by the length of the patch. The jumping of the phonograph needle will land it in a groove either behind or in advance of the projector and again make adjustment necessary.

The difference in the length of time taken to display a film and to play the phonograph record requires the individual synchronizing of a number of phonograph records, for while a standard reel of 1,000 feet of film requires approximately twenty minutes, the standard phonograph record only lasts from four to five minutes. Hence from four to five records must be replaced, started and stopped within the run of the film without loss of synchronism or speed! By the use of very large discs or cylinders the time of the phonograph has been extended, in one case at least, of fifteen minutes, but this still requires a change.

In taking the pictures, the sluggishness of the phonograph and its inability to record low sound has limited the application of the talking pictures to singing, instrumental music, and other sounds of comparatively great volume. In the recent Edison pictures, the phonograph records have been made of a specially sensitive wax that has a considerably greater range in sound volume than the material supplied with the standard machines.

SYNCHRONIZING METHODS IN GENERAL.

The earliest method of synchronizing was by unit drive, that is, the projector and phonograph were built in one unit, and were driven by a single motor. This method would not be the best for theatrical work, for the reason that the phonograph would of necessity be at the rear of the house and away from the screen where the action was taking place. As a result this class of machine was confined to toy machines or home projectors where the distance to the screen was comparatively small. By replacing the reproducer on the phonograph with a telephone transmitter and connecting this with loud speaking telephone receivers near the screen it might be possible to overcome this defect of the direct connected outfit.

In cases where the phonograph and projector are located at a considerable distance from one another, syn-

chronism is obtained in either one of two ways: first by manual or hand control, secondly by automatic devices mounted on each of the machines, one of which devices controls the opposite machine.

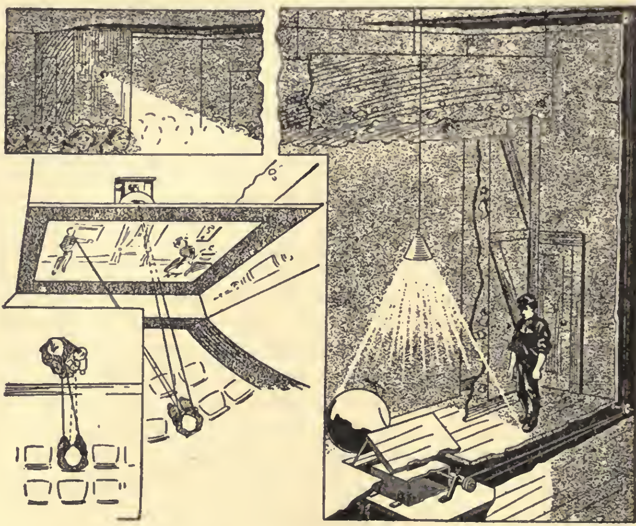
With manual control, two index hands, one for each machine, allows the attendant to keep the film and record in the proper position by watching the hands and speeding up or retarding the machines in relation to one another. If the film gets ahead of the record for example, owing to a patch, either the projector is reduced in speed, or the phonograph accelerated until the pictures are again in synchrony. As this requires constant watchfulness on the part of the operator, it imposes too great a strain on him, for this is a great addition to his already numerous duties in the operator's booth.

The automatic controls are usually operated electrically, the method in general being to connect the projector and phonograph motors on a common circuit. In some cases, both motors are run on alternating current and are of the "synchronous" type, that is, both motors keep in step with the pulsations of the current waves in the common circuit. As both motors are held in step with the same waves, it is evident that they not only will run at exactly the same speed but will turn through equal angles of any one revolution in equal times.

Another system employs two specially wound direct current motors that are timed or synchronized by a commutator on the projector motor that sends periodic current impulses through a common circuit.

A fairly comprehensive explanation of the mode of operation of the talking motion pictures expressed in terms of a mechanical simile is given in *Popular Mechanics*. A portion of it runs as follows: One of the illustrations herewith shows the connection by means of which the motion-picture machine, high up in the gallery of the theater, and the phonograph, located in a well in the stage just behind the screen or curtain, are synchronized, or made to operate at the same time and speed, so that the motion of the lips in talking and singing may be simultaneous with the utterance of the sound. Every sound or noise made by the persons producing material for the "talking" pictures is caught by a single phono-

graph recorder while the motion-picture camera is taking the pictures. In reproducing the talking pictures all that is necessary is to provide that the phonograph and the motion-picture machine be run in the same relation to each other as when the pictures were made and the sounds recorded. This is done by mechanically connecting the motion-picture projecting machine and the phonograph by means of an endless wire cable running over pulleys. The cable passes under the floor of the stage, up to the top of the proscenium arch, and across the upper regions



of the theater by air route to the motion-picture machine. Should the cable slip and so throw the two machines "out of step," so to speak, the operator of the projector can retard or increase the movement of the pictures until they are again synchronized with the phonograph. Although the sound seems to come direct from the picture of the particular person or instrument represented as producing it, no matter whether at the right, the left, or the center of the screen, it all actually comes from just one point—the horn of the phonograph. That it seems otherwise to the audience is due to the same illusion that makes ventriloquism possible. The accompanying dia-

gram illustrates the principle. Referring to this diagram two motion picture figures, going through the facial movements that accompany utterance, would, one at the extreme right and the other at the extreme left of the screen, be still close enough in line with the real source of sound so that the audience, a little distance back, could not tell from which it was coming if there were no facial movements of either, but "listening" with the eyes as well as the ears, the sound seems to come from the ones whose lips are moving. Were the screen so wide, however, that some of the talking figures might be shown a considerable distance to the right or left of the course of sound the illusion would be lost.

It should be understood however, that the writer of the above article, has for the sake of simplicity, regarded the apparatus as being mechanically driven, not caring to enter into the intricacies of the electrical features of the practical machine, a detail which if explained at this point would only confuse the lay reader.

MANUAL OR DIAL REGULATED MACHINES.

The Cinephone is one of the earliest machines of this type, having been introduced as early as 1907-1908. A quick starting phonograph is used, equipped with a small regulating dial; in other respects this machine is exactly similar to the ordinary graphophone. A similar dial with its attendant revolving hand is shown in the lower left hand corner of the pictures when thrown upon the screen. By keeping the hand of the dial on the picture in the same relative position as the dial on the phonograph, by changing the speed of the motors, the operator is able to keep the machines in synchronism, in theory at least. Practically this system is not particularly successful since it depends upon the operator, who is alwavs at least ten pictures behind with his control.

GAUMONT TALKING PICTURES.

The "Chronophone" produced by the Gaumont company in Paris, is perhaps the most successful of all talking picture devices,—except possibly the Edison. In nearly all cases the Gaumont machine is run in connection with the newly devised Gaumont colored pictures. The apparatus is almost entirely automatic in its operation.

Two motors are provided, one for the phonograph and one for the projector, both being of approximately the same construction and power. Direct current is used.

By connecting the corresponding section windings of the two armature motors together, and by feeding current through a single commutator, the two armatures are held in synchronism through the interchange of current waves, which after passing through the first armature, are alternating in character.

Should there be patches in the film, or other defects causing a slip between the phonograph and projector, the machines can be again brought into synchronism by means of a special set of differential gears driven by a small motor. A contact point in the first groove of the phonograph record starts the projector as soon as the first sound wave is reached.

Should either the pictures or the record be too far ahead, the operator closes the switch of the motor that drives the differential gear. This corrects matters almost instantly, moving the lever in one direction speeds the pictures and slows the phonograph; moving it in the other direction slows the picture and speeds the record.

A control board contains a starting gear, a switch, a speed indicator, and a two way commutator. By means of these devices, the operator can either advance or retard the phonograph or the projector.